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[THIRD SERIES.]

ART. I.—*Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Sixth paper. With plates I, II and III.

[Read before the National Academy of Sciences, Philadelphia, Oct. 18, 1876.]

Period of unusual heat in June, 1873.

IN June, 1873, an unusually high temperature prevailed throughout a large portion of the United States. At most of the Signal Service stations the thermometer rose above 90° during some part of the month, and at several of the stations there were more than ten days on which the thermometer rose as high as 90°. In the following table, column 1st shows the

Temperature of 90° *in June,* 1873.

Stations.	Latitude.	Elevation. ft.	Cases.	Stations.	Latitude.	Elevation. ft.	Cases.
Fort Sully	44° 39′	1687	17	St. Paul	44° 53′	794	5
Indianola	28 32	25	13	Boston	42 21	77	8
San Antonio	29 25	600	13	Baltimore	39 18	45	2
Mobile	30 42	41	12	Chicago	41 52	657	2
Denver	39 44	5135	11	New York	40 42	165	2
Keokuk	40 23	584	11	Toledo	41 40	649	2
Montgomery	32 22	250	11	Cleveland	41 30	682	1
Washington	38 53	105	10	Fort Garry	49 52	654	1
LaCrosse	43 48	686	8	New Haven	41 17	107	1
Cairo	37 0	352	7	Oswego	42 28	291	1
Louisville	38 18	496	7	Lexington, Ky.	38 8	1083	0
Cincinnati	39 6	614	6	Montreal	45 30	187	0
Leavenworth	39 19	813	6	Morgantown	39 40	991	0
Breckenridge	46 16	966	5	Rochester	43 8	584	0
Cheyenne	41 12	6058	5	Toronto	43 39	342	0
Omaha	41 16	1045	5				

names of the stations at which observations were made with self-registering thermometers; column 2d shows the latitude of the stations; column 3d shows their elevation above the sea, expressed in feet; and column 4th shows the number of days on which the thermometer rose as high as 90°.

The observations at Denver and Cheyenne indicate that on an elevated plateau the extreme heat of summer is at least as great as it is at the level of the sea in the same latitude; while the observations at Lexington and Morgantown show that an elevation of a few hundred feet above the surrounding country has a sensible effect in moderating the extremes of heat. The observations in the vicinity of the Great Lakes as well as those near the Ocean show that large bodies of water have a decided influence in moderating the extremes of temperature.

The stations at which the thermometer rose above 90° in more than three cases are all inland stations; and it is noticeable that at certain northern stations the heat was more intense than at any of the southern stations. At Fort Sully the thermometer rose to 108°; on seven days it rose above 100°; and on twelve days it rose as high as 95°. At Denver the thermometer rose

Observations of the thermometer at $4^h\ 35^m$ P. M., *June* 15–26, 1873.

Stations.	Mean temp. June.	Above or Below the Mean Temperature.											
		June 15.	June 16.	June 17.	June 18.	June 19.	June 20.	June 21.	June 22.	June 23.	June 24.	June 25.	June 26.
Portland, Or.	62°	+ 1	+ 5	− 2	− 1	+ 6	+ 2	− 1	− 3	+ 1	+ 1	+ 6	+ 8
San Francisco	59	+ 3	+ 7	+ 7	+ 7	+ 6	+ 1	+ 2	+ 8	+ 8	− 1	0	+15
San Diego	65	0	+ 4	+ 5	+ 2	+ 2	+ 5	+ 3	+ 2	+ 2	+ 2	+ 3	+ 5
Corinne	69	+19	+20	+14	+18	+18	+20	+13	− 8	− 5	+ 8	+14	+16
Virginia City	56	+28	+24	+12	+ 5	+13	+18	+ 3	−18	− 1	+ 9	+ 4	+ 6
Fort Benton	63	+30	+15	+18	+ 4	+ 9	+13	+ 6	− 4	+ 5	+10	− 8	+ 1
Santa Fe	69	+ 6	+ 3	+ 8	+13	+11	0	+12	+11	+10	+ 4	+12	+15
Denver	69	+12	+19	+21	+26	+13	+23	+21	+23	+15	+23	+18	+24
Cheyenne	65	+14	+22	+21	+21	+10	+25	+20	+11	− 4	+23	+24	+23
Fort Sully	70	+22	+24	+27	0	+12	+24	+25	+20	+ 8	+19	+31	+24
Yankton	71	+12	+14	+14	+10	+ 7	+14	+15	+11	+ 5	+14	+18	+20
Pembina	63	+14	+10	+13	+11	+12	+10	+ 6	+ 4	+ 8	+17	+16	+19
Fort Garry	63	+12	+20	+17	+ 2	+10	+14	+11	+ 4	+10	+10	+19	+19
Indianola	82	+ 6	− 6	− 2	+ 1	+ 5	+ 3	+ 5	+ 3	+ 3	+ 5	+ 3	+ 6
Breckenridge	65	+15	+19	+25	+25	+12	+12	+17	+13	+ 9	+19	+25	+28
Omaha	73	+13	+14	+13	+16	+ 9	+12	+ 7	+ 2	+ 8	+15	+16	+18
Leavenworth	76	+10	+11	+10	+12	+14	+10	+12	+ 7	+ 7	+10	+15	+16
Galveston	82	+ 2	− 7	− 3	− 2	+ 5	+ 7	+ 6	+ 6	+ 7	+ 6	+ 8	+ 8
Shreveport	81	− 2	− 4	+ 2	+ 2	+ 8	+ 9	− 3	+ 6	+ 7	+ 7	+11	+ 9
St. Paul	68	+17	+14	+21	+22	+11	+16	+22	+ 8	+17	+17	+ 5	+22
Duluth	58	+28	+ 2	− 2	+23	+23	+20	− 8	− 8	− 1	− 2	0	− 2
Fort Gibson	79	− 4	+ 6	+ 6	+ 6	+ 5	+ 6	+ 6	+ 7	+ 9	+10	+11	+14
Keokuk	75	+16	+11	+12	+13	+16	+10	+15	+12	+13	+18	+18	+16
LaCrosse	70	+18	+11	+19	+20	+10	+13	+16	+13	+18	+20	+17	+21
Vicksburg	81	− 5	− 3	+ 2	− 1	+ 3	+ 9	+10	+ 9	+10	+11	+ 9	+12

TABLE—continued.

ns.	Mean temp. June.	ABOVE OR BELOW THE MEAN TEMPERATURE.											
		June 15.	June 16.	June 17.	June 18.	June 19.	June 20.	June 21.	June 22.	June 23.	June 24.	June 25.	June 26.
rt......	73°	+13	+17	+14	+16	+13	+11	+10	+13	+16	+19	+18	+17
......	76	+12	+ 7	− 2	+16	+13	+ 2	+ 8	+15	+16	+16	+17	+13
......	79	+ 8	0	− 4	+ 8	+ 6	+12	+12	+14	+13	+15	− 6	+11
ans...	80	− 3	+ 5	+ 1	− 1	+ 6	+ 8	+ 9	+ 8	+ 6	+ 3	+ 7	+ 6
......	77	+10	+ 4	+ 6	+ 6	+ 7	+ 9	+10	+12	+12	+14	+ 3	+13
......	80	+ 8	− 4	+ 1	− 4	+10	+ 4	+ 3	+14	0	+12	+13	+ 2
ee	65	+12	+ 2	− 4	+26	+23	+18	+10	+ 2	+27	+ 4	+ 2	+ 9
......	68	+11	0	0	+19	+22	+ 6	+17	+13	+22	− 2	0	+ 7
e.....	58	+ 5	+ 1	+ 5	+ 7	+25	+20	− 8	− 4	+11	+ 3	+10	+16
......	60	+ 8	0	+ 6	+14	+25	+21	+ 4	+ 3	+ 3	+11	+11	+16
......	79	+ 7	− 4	+ 5	+ 7	+ 5	+10	+ 9	+13	− 3	+12	+14	0
ery...	80	+ 7	− 1	− 6	+ 6	+12	+13	+10	+12	+14	0	+13	+ 8
aven ..	65	+11	+ 7	+ 5	+15	+ 9	+ 3	+12	+13	+15	+12	+22	+14
olis ...	75	+11	+ 2	+11	+14	+15	+11	+11	+14	+18	+18	+10	+19
......	77	+10	+10	+ 9	+13	+ 9	+ 7	+10	+ 9	+16	+14	− 4	+10
i	76	+10	+15	+ 6	+ 5	+11	+11	+13	+13	+17	+18	+11	+13
......	74	+11	− 1	+ 9	+ 9	+10	+ 9	+17	+14	+11	+15	+17	+ 7
......	72	+12	+16	+ 4	+15	+18	+11	+12	+14	−11	− 5	+ 2	+11
......	60	0	+14	− 7	+28	+20	+15	− 2	− 4	− 5	+ 2	+ 2	+ 5
......	68	+12	+19	+ 5	+15	+22	+13	+17	− 1	+16	+11	+22	+12
y	79	+ 6	+ 7	+11	+13	+15	+12	+ 8	− 3	+ 5	+10	+10	− 2
essa ...	80	+ 7	+ 7	+ 8	+ 9	+ 9	+ 7	+ 5	+ 4	+ 3	− 7	+ 9	+ 6
......	79	+ 7	+10	+12	+12	+15	+12	+15	+ 9	+10	+12	+ 8	− 4
t	83	+ 5	+ 5	+ 5	+ 4	+ 5	+ 5	+ 6	+ 6	+ 6	+ 5	+ 4	+ 3
ille ...	80	+ 6	+ 9	+11	+13	+14	+16	− 1	+ 5	+ 6	+ 9	+ 7	+ 1
i	69	+ 7	+16	+ 5	+13	+20	+10	+10	+11	+13	+ 9	+ 6	+11
......	60	+ 8	+ 1	− 3	+20	+19	+ 2	− 1	+12	+ 4	+25	+15	+12
ley ...	65	+ 9	+12	+ 6	+ 8	+13	+13	+10	− 3	+ 7	− 4	+12	+ 8
......	80	+ 7	+11	+12	+13	+14	+12	+ 4	+ 6	+ 3	+ 8	+10	− 6
er	65	+ 6	+20	+ 6	+ 5	+ 9	+12	+ 3	− 6	+13	+ 2	+18	+16
n	79	+ 6	+ 9	+11	+11	+ 8	+11	+ 5	+ 4	+ 4	+10	+ 2	− 3
h	72	+11	+ 1	+11	+13	+17	+12	+13	+20	+19	+12	+ 3	+ 9
......	63	+15	+17	+ 2	+ 6	+17	+ 9	+17	− 1	− 2	+ 6	+ 7	+ 4
rg	74	− 1	+13	− 7	+ 7	+15	+16	+ 9	+13	− 1	− 1	+12	+ 4
......	65	+ 5	+ 7	+ 8	+ 6	+ 9	+11	+ 7	− 3	+14	+ 5	+16	+11
on ...	77	+ 4	+11	+ 4	+16	+17	+15	+13	+11	+12	+16	− 1	+ 3
r	66	+11	+ 4	+ 3	+16	+20	+ 7	+10	− 5	+ 7	+ 1	+12	+16
ton ...	75	− 2	+15	+16	+17	+18	+19	+11	+20	+ 4	+ 4	− 1	+10
e	75	− 5	+13	+13	+12	+18	+19	+13	+14	− 4	+ 2	+ 1	+ 6
......	64	+13	+ 9	+ 5	+15	+18	− 3	+ 4	+ 3	+12	+10	+10	+23
......	63	+ 7	+ 4	− 2	+ 5	+ 8	+13	+11	+ 6	+ 8	+12	+18	+14
......	76	−12	+13	+10	+12	+16	+20	+10	+16	+14	+14	− 9	+ 2
hia ...	72	+ 1	+13	+13	+12	+18	+18	+11	+ 8	− 7	− 8	0	+ 5
y	67	− 4	+ 2	+ 6	+ 2	+ 6	+22	+13	+ 8	+ 2	+ 1	+ 1	+ 2
k......	69	+ 1	+13	+13	+ 3	+19	+20	+12	0	− 5	− 8	0	+ 5
......	66	+ 6	+ 7	+ 1	+ 1	+ 4	+ 4	− 5	+ 1	+ 4	+ 7	+ 6	+ 7
n	66	+13	+13	+ 1	+ 6	+14	+ 9	− 6	+ 5	+11	+11	+17	+18
don...	65	+ 3	+12	+15	+ 5	+23	+22	+14	+ 5	0	− 2	+ 2	+10
hington	43	+ 4	+ 8	− 6	+ 1	+10	+ 6	− 9	− 7	+ 3	+ 5	+12	+14
......	64	+10	+10	0	−17	− 7	− 1	− 5	+ 5	+11	+13	+18	+15
......	67	+15	+22	+15	+14	+24	+18	+ 8	+ 2	+ 7	+ 6	+ 9	+21
, Me. ..	62	+ 3	+15	+14	+ 1	+ 3	+21	+ 5	+ 3	+ 4	+10	+12	+ 8
......	55	+ 3	0	+12	+10	− 6	− 1	0	+ 7	+16	+ 5	+13	+ 9

to 99°, and on five days it rose as high as 95°. At Indianola the highest temperature was 97°·5, and only twice did the thermometer rise as high as 95°. At San Antonio the highest temperature was 96°, and only once did the thermometer rise as high as 95°. At Mobile the highest temperature was 95°, and these are the highest temperatures reported at any of the southern stations. We thus see that at Fort Sully and Denver the thermometer rose higher than it did at any of the southern stations.

If we consider simply the height of the thermometer above the mean temperature of the month, we find that by far the most remarkable cases occurred at stations north of latitude 40°. The preceding table exhibits the observed changes of temperature from June 15 to June 26. Column second shows the mean temperature of June at the stations named in column first, and the succeeding columns show the difference between the mean temperature of the month and the temperature observed each day at 4^h 35^m P. M. At this hour the temperature at most of the stations is about 8° above the mean temperature of the day, so that nearly all the numbers given in this table should be diminished by about 8° in order to show the elevation above the mean temperature at the hour of observation; and at a few of the stations a still larger correction is required.

In order to exhibit more clearly the conclusions to be derived from the numbers in the preceding table I have prepared the following summary, in which column second shows for each day at what station the temperature rose *most* above the mean for the month; column third shows how much the thermometer rose above the mean; column fourth shows the state of the barometer at the given station, and column fifth shows the lowest barometer observed on the given day at any of the stations.

Temperatures most above the mean.

Date.	Stations.	Temperature.	Barom.	Lowest barom.
June 12	Fort Benton	+19°	29·97	29·64
13	Fort Sully	+21	29·68	29·68
14	Breckenridge	+19	29·59	29·46
15	Fort Benton	+30	29·80	29·63
16	Virginia City	+24	29·67	29·64
"	Fort Sully	+24	29·69	29·64
17	Fort Sully	+27	29·52	29·38
18	Alpena	+28	29·54	29·26
19	Escanaba	+25	29·52	29·49
"	Marquette	+25	29·53	29·49
20	Cheyenne	+25	29·90	29·41
21	Fort Sully	+25	29·46	29·46
22	Denver	+28	29·61	29·30
23	Milwaukee	+27	29·77	29·57
24	Saugeen	+25	30·06	29·62
"	Denver	+23	29·87	29·62
25	Fort Sully	+31	29·52	29·52
26	Breckenridge	+28	29·68	29·68

We see from this table that the stations at which the thermometer rose most above the mean were all north of lat. 39°, and they are all situated between the Rocky Mountains and the meridian of 81° west of Greenwich. We also see that a high temperature was generally accompanied by a barometer below the mean; the average pressure shown in column fourth being 29·70. Column fifth shows that on each day there was a considerable barometric depression in some part of the United States and the center of this depression was always north of lat. 40°, and the region of greatest heat was always within the influence of the area of depressed barometer. In four instances the station which showed the greatest rise of temperature showed also the greatest depression of the barometer.

In order to exhibit more clearly the form and position of these heated areas I have prepared Chart I, which shows the thermic isabnormals for June 18th, at 4^h 35^m, P. M., the curves being drawn at intervals of 5°.

From this chart we perceive that near the Gulf of Mexico, and also near the northeast and northwest angles of the United States, the temperature was below the mean for the month of June, but in every other portion of the United States the temperature was above the mean for the month. In order to determine how much the mean temperature at the hour of observation exceeds the mean temperature of the month, I have compared the observations of maxima and minima temperatures at all the Signal Service stations as far as they have been published in the annual Reports. I have taken the mean of the maxima of temperature for the month of June at each station, and also the mean of the minima. The difference between these two months I call the mean diurnal oscillation of the thermometer. I have made this comparison for each of the years 1873, 4, and 5. The following table shows all the Signal Service stations at which the mean diurnal oscillation exceeds 22°, and also all those stations at which the oscillation is less than 15°. Column second shows the mean diurnal oscillation for the month of June at the stations named in column first; column third shows the number of years of observation; column fourth shows the height of the station above the sea; column fifth shows the annual rain-fall at each station; and column sixth shows the rain-fall in 1873, from June 12th–26th inclusive.

Since we have a series of hourly observations of the thermometer at Philadelphia and Toronto we can compute the correction to be applied on account of the hour of observation at each of the preceding stations, if we assume that the correction at different stations is proportioned to the entire daily oscillation. We thus find that at the hour of 4·35 P. M., Washington

Diurnal oscillation of temperature in June.

Stations.	Oscillation	Years.	Elevation. ft.	Annual rain-fall.	Rain-fall 15 days.
Colorado Springs	33°·7	2	5935	13·69	
Denver	32·2	3	5135	13·99	0·02
Cheyenne	31·6	3	6058	8·60	0·22
Santa Fe	30·7	2	6862	13·36	0·02
Dodge City	28·2	1	2482	6·49	
Fort Sully	26·7	3	1687	12·16	0·34
Virginia City	25·7	3	5510	16·43	0·28
Salt Lake City	25·4	2	4350	17·93	0·05
Fort Garry	25·3	3	654	14·48	1·09
Ottawa	24·7	2	250	29·33	
North Platte	24:6	1	2846	13·64	
Corsicana	24·3	1	447	25·42	
Pittsburgh	23·5	1	955	37·53	0·80
Stayner	23·5	1	714	28·26	
Bismark	23·3	1	1677	21·09	
Wytheville	23·3	2	2294	44·15	
Shreveport	22·9	2	228	49·60	3·89
Pembina	22·8	2	790	12·99	1·37
Island of St. Paul	7·0	2		55·85	
Cape Hatteras	8·8	1	7	64·38	
Cape Rozier	9·7	1	39	33·81	
Key West	10·6	3	17	37·60	
Cape May	11·0	1	14	46·87	
Mt. Washington,	11·4	3	6285	66·47	
New Orleans	11·9	2	56	61·46	
San Diego	12·0	2	62	9·16	
Wood's Hole	12·1	2	25	39·36	
Galveston	12·9	2	40	46·66	
Charleston	13·0	2	61	44·18	
San Francisco	13·4	2	60	20·20	
Indianola	13·6	3	25	41·98	
Atlantic City	13·8	2	23	36·16	
Punta Rassa	13·8	2	17	53·42	
Buffalo	14·8	2	662	34·36	
Kitty Hawk	14·9	1	22	45·02	

time, the temperature exceeds the mean of the month by the following quantities:

Correction for hour of observation.

Stations.	Correc.	Stations.	Correc.	Stations.	Correc.
Denver	13°	Virginia City	10°	Saugeen	8°
Cheyenne	13	Breckenridge	9	Escanaba	7
Fort Sully	10	Alpena	8	Marquette	7
Fort Benton	10	Milwaukee	8		

Applying these corrections to the numbers given on page 4 we find that on June 15th the thermometer at Fort Benton rose 20° above the mean temperature of that station at the hour o observation; on the 18th at Alpena it also rose 20°, and on the 25th at Fort Sully it rose 21° above the mean temperature a the hour of observation. We are then required to explain how the thermometer should rise 20° above the mean temperature of the hour and place.

The accompanying Chart, Plate II, shows the isobaric curves for the same date as the temperature curves of Plate I. We perceive that throughout the entire United States, with the exception of the Pacific coast and the vicinity of the Gulf of Mexico, the pressure of the atmosphere was less than 30 inches; and in Minnesota the pressure was 29·30. This barometric minimum would lead us to look for southerly winds throughout the valley of the Mississippi. The actual direction of the winds observed is shown by arrows on Chart I. The following table shows the number of stations at which the wind blew from each of the eight principal points of the compass.

Direction of the winds, June 18th, 4^h 45^m P. M.

Wind.	No. of Stations.	Wind.	No. of Stations.
North	3	South	20
Northeast	2	Southwest	27
East	4	West	7
Southeast	7	Northwest	7

We see that at 54 stations the wind blew from some southern quarter, and at only 12 stations did it blow from a northern quarter. The following are the stations in question:

North wind at Cleveland, Mobile and Santa Fe.

Northeast wind at Duluth and Yankton.

Northwest wind at Eastport, Fort Garry, Fort Sully, Mt. Washington, Norfolk, Oswego and Pembina.

At three of these stations, viz: Cleveland, Duluth and Oswego, the northerly wind was probably the result of the cooler air of the Lakes moving toward the warmer land. Three of the stations, viz: Fort Sully, Fort Garry and Pembina, were situated on the north side of the area which was most heated; and two other stations, viz: Eastport and Mt. Washington were on the extreme eastern border of the heated area. At Mobile the velocity of the wind was only *one mile* per hour; at Norfolk and Yankton it was four miles; and at Santa Fe five miles per hour.

We thus see that throughout the entire heated area (with a few trifling exceptions which are easily explained) the movement of the atmosphere was from the south. This general movement from the south had prevailed for more than 24 hours with an average velocity of about ten miles per hour, which should cause a rise in the thermometer of from 6 to 10 degrees in the vicinity of the western Lakes; that is, this cause seems to be sufficient to account for nearly (if not fully) half of the rise actually observed.

A considerable part of the remaining rise may probably be ascribed to the accumulated effect of the sun's radiation for many successive days without the interference of northerly winds. As early as the 10th of June there was a large rise of the thermometer at Fort Benton and Virginia City, and this was maintained pretty steadily until the 17th. This heated air drifted slowly to the eastward and on the 18th reached the neighborhood of the Great Lakes.

The great diurnal oscillation of temperature observed at Denver and its vicinity, probably depends somewhat upon the configuration of the surrounding country, but the most important circumstance is the extreme dryness of the climate of this region. In a country where the annual rain-fall is small, and the surface of the earth becomes very dry, the earth readily absorbs the rays of sun, and there is little evaporation to counteract their heating effect. The thermometer therefore during the day time rises higher than it would if the earth were moist and covered with green grass. At night, on the contrary, the heat is rapidly dissipated, and there is no vapor to be condensed, which by the latent heat liberated would counteract the effects of radiation. Thus during the night the thermometer sinks lower than it would in a moist atmosphere.

The same phenomenon is noticed in other countries which have a dry climate. At Madrid in Spain the mean diurnal oscillation of the thermometer is much greater than in most parts of Europe. The following table shows the difference between the mean of the daily maxima and the daily minima at Madrid for the months of June and July during a period of eight years. The fourth column shows the highest temperature observed during each year, and the fifth column shows the rain-fall of each year expressed in English inches.

Range of thermometer at Madrid, Spain. Height, 1939 *feet.*

Years.	June.	July.	Highest temp.	Annual rain-fall.
1866	25°·2 Fahr.	29°·3 F.	101°·1 F.	19·82
1867	30·8	31·5	100·8	15·04
1868	31·1	30·2	102·7	11·83
1869	30·6	32·2	105·1	11·04
1870	32·0	32·8	104·7	12·81
1871	27·0	32·6	108·3	16·22
1872	32·8	33·1	106·3	15·30
1873	27·9	32·8	104·6	15·07
Mean	29·7	31·8	104·2	14·64

The last column in the table on page 6 shows that in June, 1873, an unusual drought prevailed throughout Colorado, Wyoming and Montana. In consequence of this extreme dryness, the heating effect of the sun's rays was greatly increased, and this cause combined with the prevalent southerly winds will probably explain the extreme heat observed in that region. The heat experienced in the neighborhood of the Great Lakes may be ascribed partly to the same causes operating in that locality, and partly to a mass of heated air drifted eastward from the dryer regions of the West.

The remarkable heat recorded at Fort Sully and mentioned on page 2, seems to indicate some peculiarity of that locality. In order to discover the nature of this peculiarity I have collected all the cases in which a temperature of 100° and upward is mentioned in the annual Reports of the Signal Service for 1873, 4, and 5. The following table shows the number of such cases for each year. For the year 1875 the observations include only the first six months of the year. The mark (*) shows that no observations of self-registering thermometers were received from the stations indicated.

Number of cases of a temperature of 100° *Fahr.*

	1873.	1874.	1875.		1873.	1874.	1875.
Fort Gibson	*	21	0	Louisville	0	3	0
Shreveport	*	3	18	Denver	0	2	0
Fort Sully	20	13	2	Dodge City	*	0	2
Leavenworth	0	12	0	Keokuk	1	2	0
Nashville	*	7	0	LaCrosse	*	2	0
Omaha	0	6	0	Augusta, Ga.	*	1	0
Cairo	0	4	0	Cincinnati	0	1	0
Corsicana	*	0	4	Indianola	0	1	0
Memphis	*	4	0	Jacksonville	*	1	0
Montgomery	0	4	0	Mobile	0	1	0
St. Louis	*	4	0	Washington	1	1	0
Dubuque	*	3	0	Yankton	*	1	0

These observations show that the thermometer seldom rises to 100° in the vicinity of the Atlantic Ocean, the Gulf of Mexico, or the Great Lakes. Cases of extreme heat are of most frequent occurrence between the Mississippi River and the Rocky Mountains. They are the effect of the dryness of the soil and of the atmosphere in that region; and they serve to intensify the dryness from which they result. If we compare the high temperatures observed at Fort Sully with the observations at neighboring stations, we shall perceive that they are altogether exceptional. The first column of the following table shows a series of stations on the Missouri River; column second shows the latitude of the stations; column third shows their elevation (in feet) above the ocean; and column fifth shows the number of cases in which the thermometer, in 1873, 4, and 5, was observed to rise as high as 100°.

Temperature of 100° *Fahr.*

	Latitude.	Elevation.	Cases.
Leavenworth	39° 19′	813	12
Omaha	41 16	1045	6
Yankton	42 45	1296	1
Fort Sully	44 39	1687	35
Bismark	46 48	1677	0

The first three stations, together with the fifth, show a steady decline in the intensity of the heat as we advance northward; but Fort Sully shows temperatures much greater than occur at stations several hundred miles southward. At this station the meteorological instruments are located within the walls of the fort, and the thermometers are probably influenced by heat reflected from dry sand, and stone walls. This seems to be the most probable explanation of the excessive heat reported at Fort Sully.

Rain-areas—their form, movements, distribution, etc.

In order to investigate the form of rain-areas; the laws which govern their movements, and their relations to the isobaric curves I selected all those cases during a period of fifteen months (Sept. 1872 to Nov. 1873) in which at least two inches of rain fell at one station in eight hours. These cases were then divided into two classes, one containing the stations south of latitude 36°, and the other containing the stations north of latitude 36°. The following table exhibits all the cases which occurred at the southern stations. Column first contains the number of reference, column second shows the day and hour of observation (the numeral one denotes the 7.35 A. M. observation; two denotes 4.35 P. M., and three denotes 11 P. M.); column third shows the station at which the greatest rain-fall was observed; column fourth shows the precise amount of the rain: column fifth shows the height of the barometer at the same station; column sixth shows the direction and force of the wind at the last *preceding* observation; column seventh shows the direction and force of the wind at the date given in column second; column eighth shows whether the direction of the winds at the neighboring stations indicated a cycloidal or inward motion; column ninth shows whether there was any local depression of the barometer; and column tenth shows whether there was a high or a low barometer on the north side of the given station.

For a large number of these cases I have drawn upon maps of the United States, the curves of equal rain-fall for each fourth of an inch. These curves show that when there is only one principal center of precipitation, the form of the rain-area is nearly circular, and its diameter varies from 350 to 750 miles.

Rain-fall of two inches at Stations south of lat. 36°.

Date.	Station.	Rain. In.	Bar.	Wind at prev. ob.	Wind at date.	Cycloidal motion.	Local dep'n.	On N. side.
1872.								
pt. 10–2	Jacksonville.	2·42	30·09	S.E. 3	N. 2	probable	none	low
11–2	Montgomery.	2·00	29·93	E. 4	S.E. 2	decided	slight	low
25–1	Shreveport.	2·05	30·11	W. 5	N.E. 14	decided	none	low
26–1	Wilmington.	2·09	30·05	Calm	S. 4	decided	none	high
30–1	Charleston.	2·07	30·01	S.W. 6	N.E. 6	decided	none	low
t. 9–2	New Orleans.	2·19	29·96	E. 8	E 8	decided	slight	high
22–2	Punta Rassa.	2·06	29·92	E. 23	S.E. 15	decided	slight	high
22–3	Jacksonville.	2·43	29·99	N.E. 12	E. 13	decided	slight	high
23–1	Jacksonville.	2·05	29·83	E. 13	W. 1	very dec'd	decided	high
29–2	Shreveport.	2·24	29·95	Calm	S.W. 10	not dec'd	slight	low
v. 6–1	Galveston.	3·75	29·76	E. 2	S.E. 28	decided	decided	low
6–3	Montgomery.	2·73	29·95	E. 3	S.E. 22	decided	slight	high
8–1	New Orleans.	3·15	29·85	N.E. 16	N. 18	decided	slight	high
8–2	Mobile.	2·04	29·84	N.E. 8	E. 12	decided	decided	high
c. 10–1	Indianola.	2·14	29·86	N.E. 35	N. 40	decided	slight	high
18–2	New Orleans.	2·20	30·08	S.W. 6	N.E. 8	decided	none	high
1873.								
n. 5–1	Lake City.	2·00	29·89	S.E. 4	S.E. 7	decided	slight	low
16–1	New Orleans.	2·01	29·92	S. 8	N.W. 12	decided	slight	low
r. 29–1	Lake City.	2·00	29·97	N.E. 8	N.W. 12	decided	slight	low
ril 29–2	Savannah.	2·15	29·99	S. 10	Calm	slight	slight	low
y 1–2	Montgomery.	3·05	29·87	S.E. 4	S.E. 4	slight	slight	low
5–3	New Orleans.	2·40	29·81	E. 12	E. 16	decided	decided	low
6–1	Mobile.	2·34	29·85	N.E. 6	N.E. 16	decided	decided	low
18–2	Galveston.	2·00	29·77	S.E. 16	N.E. 22	decided	decided	low
19–2	Mobile.	2·47	29·99	N W. 1	N. 8	not dec'd	none	low
20–2	New Orleans.	2·08	29·92	N. 3	S.E. 12	slight	slight	low
ne 1–1	Key West.	2·05	30·00	N.E. 2	S.W. 6	decided	slight	high
8–2	Mobile.	2·10	30·01	S.W. 2	W. 1	decided	small	low
10–3	Memphis.	2·68	29·98	S.E. 8	N.E. 4	decided	small	
ly 21–2	Mobile	2·30	30·07	N. 4	S. 8	decided	none	low
22–2	Mobile.	3·14	30·18	N.E. 16	E. 16	slight	none	low
g. 2–2	Punta Rassa.	3·32	30·06	N.E. 4	N. 2	decided	none	low
6–1	Charleston.	2·05	30·23	N.E. 4	N.E. 8	none	none	high
8–3	Vicksburg.	2·00	30·08	Calm	Calm	not dec'd	none	high
9–2	New Orleans.	2·03	30·02	E. 12	E. 10	doubtful	not dec'd	low
17–3	Punta Rassa.	2·69	30·11	S.W. 13	E. 5	not dec'd	none	high
20–2	Jacksonville.	3·72	30·06	S.E. 4	E. 20	decided	none	high
21–1	Galveston.	3·67	29·95	E. 5	Calm	decided	slight	low
21–2	Mobile.	2·04	29·96	N.E. 4	E. 8	decided	slight	low
30–2	Indianola.	2·16	30·20	S.E. 20	N. 6	not dec'd	none	low
pt. 13–2	Galveston.	2·95	29·97	N.E. 9	N.E. 14	not dec'd	not dec'd	high
18–1	Mobile.	2·35	29·90	N.E. 7	E. 12	decided	small	low
18–2	Mobile.	2·73	29·90	E. 12	E. 12	decided	small	high
20–1	Wilmington.	2·38	29·82	N.E. 8	N.W. 14	decided	small	low
26–2	Indianola.	2·96	29·85	S.E. 20	S. 14	doubtful	not dec'd	low
t. 3–1	Jacksonville.	2·74	30·04	N. 12	N.W. 4	doubtful	not dec'd	high
v. 1–1	Havana.	2·80	30·11	N.E. 11	N.E. 10	doubtful	small	high
2–3	Galveston.	3·50	30·05	S. 16	S. 12	decided	small	high
5–2	Montgomery.	2·97	30·06	Calm	S.E. 1	decided	small	high
17–2	Havana.	2·88	29·73	S.W. 5	N.W. 6	probable	doubtful	low
22–3	Shreveport.	2·16	29·80	N. 5.	S.E. 5	decided	decided	low
29–1	Havana.	2·10	30·18	N.W. 6	N.E. 4	probable	doubtful	high

These excessive rain-falls are not of long continuance, but their exact duration cannot be determined from the observations. In two cases (viz., Nos. 8 and 42) over two inches of rain fell in two successive periods of eight hours at the same station; and in a few other cases these great rain-falls were followed during the next eight hours by a fall of one inch or more, either at the same station, or at a station a little to the eastward. The following table shows all the cases in which any of these heavy rain-falls were followed by one inch of rain at a neighboring station during a succeeding period of eight hours.

Cases of heavy rain continuing more than eight hours.

Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.
1872.											
Sept. 11–2	2·00	Montgomery.	11–3	1·10	Lake City.						
Oct. 22–2	2·06	Punta Rassa.	22–3	2·43	Jacksonville.	23–1	2·05	Jacksonville.	23–2	1·58	Charleston.
Nov. 6–1	3·75	Galveston.	6–2	1·88	Galveston.	6–3	2·73	Montgomery.			
Nov. 8–1	3·15	New Orleans.	8–2	2·04	Mobile.						
Dec. 10–1	2·14	Indianola.	10–2	1·03	Galveston.						
1873.											
Jan. 5–1	2·00	Lake City.	5–2	1·19	Norfolk.						
May 1–2	3·05	Montgomery.	1–3	1·80	New Orleans.						
May 5–3	2·40	New Orleans.	6–1	2·34	Mobile.	6–2	1·11	Montgomery.	6–3	1·64	Jacksonville.
May 20–2	2·08	New Orleans.	20–3	1·21	New Orleans.						
Aug. 21–1	3·67	Galveston.	21–2	2·04	Mobile.						
Sept. 18–1	2·35	Mobile.	18–2	2·73	Mobile.						
Oct. 3–1	2·74	Jacksonville.	3–2	1·25	Jacksonville.						

In three cases we find three successive periods of heavy rain-fall, and in two cases we find four such periods, indicating a duration of heavy rain for thirty-two hours. We conclude therefore that great rain-falls do not generally continue over eight hours, and very rarely do they continue for twenty-four hours, either as experienced at one station, or in succession at different places.

These heavy rain-falls appear to result from the unstable condition of the different strata of the atmosphere. When the atmosphere near the earth's surface becomes unusually heated it tends to ascend; and if this atmosphere contains a large amount of aqueous vapor, its specific gravity is thereby diminished and it has a much stronger tendency to ascend. It thus frequently happens that the atmosphere is in a state of unstable equilibrium, and a slight cause is sufficient to determine a strong upward movement of the surface air, resulting in a precipitation of vapor. When air in this unstable condition has a movement along the earth's surface, a slight inequality of the surface may be sufficient to determine an upward movement at that point. We should therefore conclude that when a current of warm and moist air flows in from the ocean and impinges upon the land, a strong upward movement accompanied by heavy precipitation must frequently result. This conclusion is confirmed by a comparison of the preceding observations. Among the stations of the Signal Service south of latitude 36°, there are twelve stations situated on the Atlantic coast or the Gulf of Mexico. At these stations during a period of fifteen months the average number of great rain-falls (two inches in eight hours) has been 3·6. Among the stations of the signal service south of latitude 36°, there are also five inland stations, whose average distance from the coast is 200 miles, and during the same period the average number of great rain-falls at these stations has been 1·8; that is, near the coast great rain-falls occur *twice* as frequently as they do at stations in the interior at a distance of 200 miles from the coast.

Whenever a strong upward movement of the air commences, there must be a general tendency of the surrounding air toward this point, and the air must circulate from right to left as it does in great storms. Hence every great rain-storm should be accompanied by an inward and cycloidal motion of the air. In about two-thirds of the preceding cases there is decided evidence of the existence of such a cycloidal movement, and in most of the remaining cases there are some indications of such a movement. If observations could be obtained from a sufficient number of stations, it is believed that some degree of cycloidal motion would be indicated in every case of heavy rain-fall.

The depression of the barometer attending these rain-falls was generally small, nevertheless in several cases it was quite appreciable. At the time of the observations shown in the table on page 11, the average height of the barometer was less than thirty inches, while the mean height throughout the year at the same stations was nearly 30·10 inches. That a cycloidal movement of the air should produce so little depression of the barometer is due to three circumstances; first, the small velocity of the wind (averaging less than nine miles per hour); second, the small area of the cycloidal movement (generally about 500 miles in diameter), and third, the proximity of the stations to the equator. According to Ferrel's formula any great barometric depression requires a strong wind; the cycloidal movement must extend over a large area; and the depression of the barometer is proportioned to the sine of the latitude of the place. In about half of the preceding cases there was an area of low barometer prevailing in the northern portion of the United States, and about as frequently, there was an area of high barometer on the northern side of the station. These different conditions appear to be about equally favorable to heavy rain-falls.

The distribution of these fifty-two cases by seasons was as follows:

Spring, 8; Summer, 14; Autumn, 14 and 12; Winter, 4.

We thus see that great rain-falls are most frequent when the heating effect of the sun's rays is greatest and the atmosphere contains the greatest amount of vapor.

The distribution of these cases according to the hours of the day was as follows:

At the 7.35 A. M. obs.	19 cases.
4.35 P. M.	25 "
11.00 P. M.	8 "

The intervals between the observations, which for convenience I have called eight hours, are in fact unequal. Making, however, due allowance for inequality of intervals, it seems clear that in the United States, south of latitude 36°, heavy rain-falls are less frequent from 4.35 P. M. to 11 P. M., than during the remainder of the day. If we knew the precise time of beginning and end of each rain-fall we might determine the precise hour of maximum and of minimum frequency of heavy rain-falls.

On Plate III are shown the curves of equal rain-fall for June 10, 1873, being No. 29 of the table on page 11. The outer curve shows the extreme limits of the rain-area; the next curve shows the limits of a rain-fall of one inch; and the inner curve shows the limits of a rain-fall of two inches. The arrows show the direction of the wind as reported at 4.35 P. M., which is presumed to have been about the time of the commencement of the rain-fall. There was a center of low pressure (29·71) near Lake Ontario, and a center of high pressure (30·16) near Charleston, S. C. As the result of this unequal pressure, southerly winds generally prevailed throughout the Southern States. A northwest current had however set in from the neighborhood of Minnesota, and this wind had reached St. Louis and Fort Gibson. The temperature at St. Louis was 71°, while at Memphis it was 87°. This cooler wind from the northwest probably flowed under the southeast wind from Memphis, causing it suddenly to ascend, and thus produced a rapid precipitation of vapor.

Rain-fall of two inches at stations north of lat. 36°.

The following table contains all the cases in which at least two inches of rain fell in eight hours at any of the northern stations from Sept., 1872, to Nov., 1873. Column 1st contains the number of reference; column 2d shows the day and hour of observation; column 3d shows the station at which the

Rain-fall of two inches at stations north of lat. 36°.

No.	Date.	Station.	Rain. In.	Bar.	Wind		Rain center from Low.		Low bar.
					at prev. ob.	at date.	Direction.	Distance.	
	1872.								
1	Sept. 23–2	Grand Haven.	2·89	29·77	S.E. 6	S.E. 7	East	660	29·35
2	26–2	Mt. Washington.	2·27	30·14	S.W. 43	S.W. 32	S. 80 E.	733	29·59
3	28–3	Chicago.	2·02	29·35	N.E. 22	N.E. 11	*	00	29·35
4	Oct. 25–1	Norfolk.	3·41	29·95	E. 13	S.E. 8	*	00	29·95
5	26–1	Philadelphia.	2·09	29·78	E. 20	S.W. 12	S. 54 E.	137	29·74
6	Nov. 7–1	New York.	2·50	29·68	S.E. 4	N.W. 10	S. 65 E.	777	29·33
7	Dec. 26–1	Norfolk.	2·08	29·46	N.E. 21	N. 20	*	00	29·46
	1873.								
8	Jan. 5–2	Philadelphia.	2·18	29·61	N.E. 20	N.E. 8	S. 58 E.	218	29·45
9	May 1–1	Nashville.	2·20	29·73	S.E. 4	E. 25	S. 64 E.	420	29·58
10	9–2	New London.	2·35	30·06	N.E. 4	N.E. 26	N. 83 E.	696	29·62
11	22–1	Lynchburg.	2·10	30·00	N.E. 4	Calm	S. 80 E.	886	29·45
12	June 9–3	St. Louis.	2·93	29·87	S. 8	S. 5	S. 21 W.	420	29·70
13	22–3	St. Paul.	2·28	29·55	S.E. 13	S.E. 18	N. 70 E.	185	29·43
14	23–1	St. Paul.	2·30	29·57	S.E. 18	S.W. 2	S. 70 E.	88	29·52
15	July 2–1	Indianapolis.	2·04	29·94	S.E. 12	S.W. 3	S. 5 E.	218	29·77
16	16–1	Marquette.	2·10	29·94	Calm	S. 8	N. 88 E.	549	29·47
17	16–2	Fort Garry.	2·45	29·49	E. 10	S. 5	*	00	29·49
18	17–3	Buffalo.	2·00	29·64	S.W. 14	S.W 7	*	00	29·64
19	26–1	Buffalo.	2·20	29·83	S.E. 4	Calm	N. 56 E.	160	29·81
20	27–2	Washington.	2·12	30·11	S. 10	W. 8	S. 63 E.	1175	29·72
21	27–3	Philadelphia.	2·03	30·16	N.W. 8	S. 8	S. 64 E.	1140	29·85
22	Aug. 13–1	Philadelphia.	2·31	30·04	E. 16	N.E. 12	N. 70 E.	360	29·92
23	13–2	Philadelphia.	2·17	29·97	N.E. 12	N.E. 22	N. 40 E.	350	29·85
24	13–3	Baltimore.	3·26	29·86	N.E. 12	N.E. 12	North	40	29·86
25	14–1	Breckenridge.	2·05	29·86	S. 16	S.E. 16	N. 53 E.	187	29·71
26	25–2	Erie.	2·00	29·82	S.E. 1	W. 4	North	312	29·70
27	Sept. 10–1	Norfolk.	2·05	30·16	Calm	E. 4	N. 22 E.	668	29·97
28	19–3	Mt. Washington.	2·20	29·86	S.W. 24	W. 12	North	202	29·59
29	Oct. 7–1	Portland, Me.	2·02	29·40	N. 12	N. 20	*	00	29·40
30	19–3	New London.	2·25	29·80	S.E. 2	S.E. 24	N. 34 E.	329	29·52
31	Nov. 24–2	New London.	2·80	29·30	S.E. 14	N. 1	S. 61 W.	90	29·27

greatest rain-fall was observed; column 4th shows the precise amount of the rain-fall; column 5th shows the height of the barometer at the same station; column 6th shows the direction and force of the wind at the last *preceding* observation; column 7th shows the direction and force of the wind at the date given in column 2d; column 8th shows the direction of the rain center from the nearest center of low pressure; column 9th shows the distance of the rain center from the center of low pressure, expressed in miles; and column 10th shows the height of the barometer at the center of low pressure.

In all of these cases there was an area of low pressure within the limits of the United States, and generally the place of greatest rain-fall was within the cycloidal movement attending this low pressure. The distance of the rain center from the center of low pressure was however very variable.

In 16 cases the distance was less than 250 miles.
6 " " between 250 and 500 miles.
5 " " between 500 and 750 miles.
4 " " over 750 miles.

In the two cases of July 27th, the low pressure was so inconsiderable and remote as to exert very little influence upon the winds at Philadelphia and Washington.

We thus see that north of lat. 36° great rain-falls generally occur within 250 miles of a center of low pressure, and almost invariably on the east side of the low center. In two of the preceding cases (Nos. 12 and 31) the rain center is stated to be west of the low center. But it should be remembered that the rain-fall occurred during the eight hours preceding the date of the barometric observation. The middle of the rain-fall may be regarded as corresponding to a date four hours preceding the barometric observation, and during these four hours, the low center generally advances eastward 100 miles. We may therefore conclude that in No. 31 the principal rain-fall occurred when the rain center was east of the low center. In No. 12 the principal rain-fall occurred on the southwest side of the low center, but the barometric gradient was only one-tenth of an inch to 350 miles. The rain center occurs as frequently in the N.E. quarter from the low center as it does in the S.E. quarter.

The four cases in which the rain center was more than 750 miles distant from the nearest center of low pressure were Nos. 6, 11, 20 and 21. In No. 6 a distinct local cyclone formed near New York, accompanied by a slight local depression of the barometer, which had the effect of urging the low center eastward with extraordinary velocity. From 7.35 A.M. to 4.35 P.M., that is, in nine hours, the low center advanced eastward 900 miles, although the greatest velocity of the wind, recorded anywhere near the path of the storm, was thirty-eight miles per hour (on Mt. Washington), indicating that the progress of the low center was not due wholly to the transfer of air from west to east, but rather to a *diminution* of the pressure on the east side of the low, and an *increase* of the pressure on its western side.

In No. 11 Lynchburg was somewhat nearer to a center of high pressure than of low pressure. There are indications that a small local cyclone formed about Lynchburg, but the stations of observation are too few to show this conclusively.

In Nos. 20 and 21 the rain center was much nearer to a center of high pressure than of low pressure. At 4.35 P. M. a distinct local cyclone was shown about Baltimore, Washington, and Cape May, but the cyclonic area was of small diameter and its effect upon the barometer was scarcely appreciable.

We thus see that great rain-falls may occur under the influence of an area of high pressure as well as of low pressure, and when they occur at a great distance from a low center, they are generally accompanied by a distinct local cyclonic movement of the atmosphere.

Of the thirty-one cases included in the preceding table, fifteen occurred on the Atlantic coast, and the number of stations of observation upon the coast was eleven; which shows an average of 1·37 to each station. For the remainder of the United States there were sixteen cases, and the number of stations was fifty-nine, showing an average of 0·27 to each station. Thus we see that north of lat. 36° near the Atlantic coast, great rain-falls are *five times* as frequent as in other parts of the United States in the same latitude. The frequency of heavy rain-falls in the neighborhood of the great lakes is not sensibly greater than at inland stations quite distant from the lakes.

The distribution of these 31 cases by seasons was as follows:

Spring 3; summer 15; autumn 6 and 5; winter 2.

Showing a predominance of great rain-falls in summer even more decided than at the southern stations.

The distribution of these cases according to the hours of the day was as follows: 7·35 A. M., 14 cases; 4·35 P. M., 9 cases; 11 P. M., 8 cases.

If we correct these numbers for the inequality of the time intervals, there is still an excess of cases for the morning hour of observation.

The following table shows all the cases in which any of these heavy rain-falls were followed by at least one inch of rain during a succeeding period of eight hours.

At the southern stations, out of fifty-two cases of heavy rain there were twelve cases in which heavy rain continued through two periods of eight hours; at the northern stations out of thirty-one cases there were thirteen which continued through two periods, indicating that heavy rains are of longer duration at the northern stations than they are at the southern. In two instances the center of the rain area apparently moved westward. Thus on the morning of July 16tn, the center of the rain area was at Marquette, which was more than 500 miles eastward of the center of low pressure; but in the afternoon the center of the rain area coincided with the center of low pressure; that is, the center of the rain area moved toward the northwest. So also on the morning of May 1st, the center of the rain area was more than 400 miles eastward of the center of low pressure; in the afternoon the center of the rain area extended southward; and during the evening it extended toward the southwest.

Cases of heavy rain continuing more than eight hours.

Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.
1872.								
Sept. 26–2	2·27	Mt. Washington.	26–3	1·20	Mt. Washington.			
28–3	2·02	Chicago.	29–1	1·31	Grand Haven.			
Oct. 25–1	3·41	Norfolk.	25–2	1·45	New York.			
Nov. 7–1	2·50	New York.	7–2	1·49	New London.			
1873.								
May 1–1	2·20	Nashville.	1–2	3·05	Montgomery.	1–3	1·80	New Orleans.
June 9–3	2·93	St. Louis.	10–1	1·07	St. Louis.	10–2	1·50	Indianapolis.
22–3	2·28	St. Paul.	23–1	2·30	St. Paul.			
July 16–1	2·10	Marquette.	16–2	2·45	Fort Garry.			
17–3	2·00	Buffalo.	18–1	1·05	Mt. Washington.			
27–2	2·12	Washington.	27–3	2·03	Philadelphia.			
Aug. 13–1	2·31	Philadelphia.	13–2	2·17	Philadelphia.	13–3	3·26	Baltimore.
Oct. 7–1	2·02	Portland, Me.	7–2	1·60	Eastport.			
19–3	2·25	New London.	20–1	1·96	Burlington.	20–2	1·38	Mt. Washington.

The average direction and force of the wind during these cases of heavy rain-fall both for the southern and northern stations was as follows:

		Direction.	Force.
South of latitude 36°.	At previous obs.	N. 79° E.	8·1
	at date,	N. 75° E.	9·9
North of latitude 36°.	At previous obs.	S. 69° E.	11·8
	at date,	S. 39° E.	11·3

We thus see that both at the northern and southern stations heavy rains are generally accompanied by easterly winds. At the northern stations southeast winds are most prevalent, while at the southern stations northeast winds are most prevalent. At the southern stations there are but eleven cases in which east winds are not reported either at date or at the preceding observation. These exceptions are Nos. 4, 10, 18, 20, 25, 28, 30, 34, 46, 48 and 50. In four of these cases the force of the wind was reported 0; in two of them it was reported as one mile per hour; in two cases it was four miles per hour; in one case it was five miles; in one case eight miles and in one case twelve miles per hour. We thus see that during a heavy rain-fall, the wind either blows from some eastern quarter, or its velocity is almost invariably small.

At the northern stations there are but eight cases in which east winds are not reported either at date or at the preceding observation. These exceptions are Nos. 2, 12, 16, 18, 20, 21, 28 and 29. Two of these cases occurred on the summit of Mt. Washington; in one of the remaining cases the velocity of the wind was 0; in one it was five miles per hour; in one it was seven miles; in two it was eight miles; and in one it was twelve miles per hour. We thus see that at the northern stations as well as at the southern, during a heavy rain-fall the wind blows from some eastern quarter, or its velocity is almost invariably small.

On Plate III are shown the curves of equal rain-fall for Sept. 23, 1872, being No. 1 of the table on page 15. The outer curve shows the extreme limits of the rain area and the other curves show the limits of a rain fall of one inch and of two inches. The arrows show the direction of the wind at 7 A. M., which was previous to the middle of the rain fall. There was a center of low pressure (29·35) near Omaha, which was about west of the center of the rain area and distant from it 660 miles. Near the Atlantic coast there was a belt of high pressure (30·25). The result of this unequal pressure was a general prevalence of southeast winds throughout a large part of the Mississippi valley. Northerly winds commenced blowing from the neighborhood of Lakes Superior and Huron, being the result of a lower temperature and a higher pressure. This colder wind from the north probably flowed under the southeast wind which had been blowing over Lake Michigan and produced that strong upward movement of the air which was followed by excessive rain at Grand Haven and Milwaukee.

In a large number of the cases in the table on page 15 the observations show that a southeast wind at certain stations was opposed by a westerly or northerly wind at other stations. This opposition or interference of winds generally results in a cycloidal movement, and the observations clearly indicate such a movement in nearly all of the cases in the table on page 15. When the rain area was remote from the center of low pressure this cycloidal movement was local and limited to a small area and did not generally exert a decided influence upon the isobaric curves.

In preparing the materials for this article I have been assisted by Mr. Edward S. Cowles, Ph.D., a graduate of Yale College of the class of 1873.

ART. II.—*On Some Points in Connection with Vegetation:* by DR. J. H. GILBERT.*

THE subject of vegetation is such a very wide one, and might be treated of in so many different ways, that it seems desirable to state at the outset what is the scope, and what are the limits, of the discussion which I propose to bring before you. I propose, then, to confine attention almost exclusively to the question of the *Sources of the nitrogen of vegetation in general, and of agricultural production in particular.* I propose further to treat of this subject mainly in the aspects in which it has forced itself upon the attention of Mr. Lawes and myself during the now thirty-three years of our agricultural investigations; and, also, in so far as it illustrates, and is illustrated by, the objects contributed by Mr. Lawes to the Exhibition around us.

Before entering upon the special subject matter of my discourse, I must claim the indulgence of those present, who are already well acquainted with the main facts of the chemistry of vegetation, while I call attention, very briefly, to some rather elementary matters, with a view of rendering what has to follow the more intelligible to any who may be less fully informed on the subject.

When a vegetable substance is burnt—as a familiar instance, let us say tobacco, for example—the greater part of it is dissipated, but there remains a white ash. The ashes of crude or unripe vegetable substances are found on analysis to contain most, or all, of the following constituents, namely:—

Oxide of iron, oxide of manganese, lime, magnesia, potass, soda, phosphoric acid, sulphuric acid, chlorine, and silica.

Rarer substances than these are also sometimes found. Now, much has of late years been established in regard to the occurrence, and the offices, of some of these substances in plants; but I do not propose to touch upon the questions herein involved. It will suffice further to say in regard to these incombustible, or "mineral" constituents, that the ash of one and the same description of plant, growing on different soils, may, so long as it is in the growing or immature state, differ very much in composition. Again, the ashes of different species, growing on the same soil, will differ very widely in the proportion of their several constituents. But it is found that the nearer we approach to the elaboration of the final products of the plant—the seed, for example—the more fixed is the composition of ash of such products of one and the same species. In other words, there is very little variation in the composition of the ash of one and the same description of seed, or other final product, provided it be evenly and perfectly matured. This fact alone, independently of all that has been established of late years in regard to the office or function, so to speak, of individual mineral constituents of plants, would be sufficient to indicate the essentialness of such constituents for healthy growth; and it is obvious that they must be provided *within the soil.*

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* **An address delivered at South Kensington, in the Chemical Section of the Science Conferences, by Dr. J. H. Gilbert, F.R.S., F.L.S., F.C.S.**

But now as to the combustible constituents—the carbon, the hydrogen, the oxygen, and the nitrogen. Leaving out of consideration such exceptional cases as those brought to light in Mr. Darwin's beautiful investigation on insectivorous plants, and also the sources of the organic substance of fungi, and perhaps of some forced horticultural productions, it may be stated, that the source of the carbon of vegetation generally is the carbonic acid existing in very small proportion, but in large actual amount, in the atmosphere; that the source of the hydrogen is water; and that the source of the oxygen may be either that in carbonic acid, or that in water. With regard to the nitrogen the case is, however, by no means so simple. Not that there are no questions still open for investigation in regard to the assimilation by plants of their incombustible or mineral constituents, or of their carbon, their hydrogen, and their oxygen; but those relating to the sources, and to the assimilation, of their nitrogon, are not only in many respects of more importance, but seem to involve greater difficulties in their solution.

What, then, are the sources of the nitrogen of vegetation? Are they the same for all descriptions of plants? Are they to be sought entirely in the soil? or entirely in the atmosphere? or partly in the one, and partly in the other?

Amount of nitrogen carried down by atmospheric precipitation.—As the combined nitrogen coming down from the atmosphere in rain, hail, snow, mists, fog, and dew, does undoubtedly contribute to the annual yield of nitrogen in our crops, let us first briefly consider what is known as to the amount of it annually so coming down over a given area of the earth's surface; and as we are here discussing the subject in England, I will adopt the English pound as the unit of weight, and the English acre as the unit of area. The following table shows the amount of nitrogen coming down as ammonia and nitric acid in the total rain, hail, snow, and some of the minor deposits, during the years 1853, 1855, and 1856, at Rothamsted (Herts), the nitric acid being in all cases determined by Mr. Way, and the ammonia in some cases by him, and in others by ourselves:—

TABLE I.—*Combined Nitrogen in Rain and Minor Aqueous Deposits at Rothamsted.*

	Nitrogen per acre, per annum, lbs.			
	1853.	1855.	1856.	Mean.
As ammonia............	5·67	5·86	7·85	6·46
As nitric acid............	(not determined)	0·77	0·73	0·75
Total		6·63	8·58	7·21

Numerous determinations of the ammonia and nitric acid in rain, and the other aqueous deposits, have been made in various parts of France and Germany, some in the vicinity of towns, and some in the open country. Of the latter, which are the most to our purpose, it may be stated that those of Boussingault at Liebfrauenberg, in Alsace, generally indicate a larger proportion of the nitrogen existing as nitric acid, and less as ammonia than our own; but, upon the whole, the observations in the two widely separated localities mutually confirm one another. Of the results of others, in other localities, some show about the same amount of combined nitrogen so deposited as our own, some, however, much more, and some much less, than ours; but the determinations on the Continent generally show a higher proportion of the total combined nitrogen to exist as nitrates than those in this country. It may be added, that numerous determinations of the combined nitrogen in rain, dew, etc., collected at Rothamsted, have much more recently been made by Professor Frankland, and his results, which are published in the "Sixth Report of the Rivers Pollution Commission," are substantially confirmatory of the earlier determinations, summarized in the foregoing Table, but upon the whole they indicate lower amounts. Lastly, M. Marié-Davy determined the ammonia in the rain, etc., collected at the Meteorological Observatory at Montsouris, Paris, during the last six months of 1875; and the amount of ammonia so coming down, even within the walls of Paris, represented only 5·25 lbs. of combined nitrogen per acre, or only 10·5 lbs. per acre, per annum. M. Marié-Davy did not make a complete series of determinations of the nitric acid in the meteoric waters, but his initiative results agree with the experiments of others in showing the amount of combined nitrogen to be comparatively small.

Thus, the determinations hitherto made of the amount of combined nitrogen coming down in the measured aqueous deposits from the atmosphere, do not justify us in assuming that the quantity available from that source will exceed eight or ten lbs. per acre, per annum, in the open country, in Western Europe. It should be observed, however, that the amount of ammonia especially is very much greater in a given volume of the minor aqueous deposits than it is in rain; and there can be little doubt that there would be more ammonia deposited from them within the pores of a given area of soil, than on an equal area of the non-porous even surface of a rain gauge. How much, however, would thus be available to the vegetation of a given area beyond that determined in the collected and measured aqueous deposits, we have not the means of estimating with any certainty. On the other hand, numerous independent determinations, by both Dr. Voelcker and Dr. Frankland, of the nitric acid in the drainage-water collected from land at Rothamsted which had been many years unmanured, lead to the conclusion that there may be a considerable annual loss of nitrogen by the soil in that way.

Amount of nitrogen derived by crops of different kinds when grown without manure.—The next point to consider is, what is the amount of nitrogen annually obtained over a given area, in different crops, when they are grown without any supply of it in manure. This point may be illustrated by the results obtained in the field experiments on Mr. Lawes' farm at Rothamsted, which have now been in progress for about a third

TABLE II.—*Yield of Nitrogen per acre, per annum, in Wheat, Barley, and Root Crops, at Rothamsted.*

Crop. &c.	Condition of Manuring, &c.		Duration of Experiment.	Average Nitrogen per acre, per annum.
				lbs.
Wheat.	Unmanured		8 yrs. 1844-'51	25·2
			12 yrs. 1852-'63	22·6
			12 yrs. 1864-'75	15·9
			24 yrs. 1852-'75	19·3
			32 yrs. 1844-'75	20·7
	Complex Mineral Manure		12 yrs. 1852-'63	27·0
			12 yrs. 1864-'75	17·2
			24 yrs. 1852-'75	22·1
Barley.	Unmanured		12 yrs. 1852-'63	22·0
			12 yrs. 1864-'75	14·6
			24 yrs. 1852-'75	18·3
	Complex Mineral Manure		12 yrs. 1852-'63	26·0
			12 yrs. 1864-'75	18·8
			24 yrs. 1852-'75	22·4
Root Crops.	Complex Mineral Manure.	Turnips	8 yrs. 1845-'52	42·0
		Barley	3 yrs. 1853-'55	24·3
		Turnips	15 yrs. 1856-'70*	18·5
		Sugar-beet	5 yrs. 1871-'75	13·1
		Total	31 yrs. 1845-'75	26·8

* Thirteen years' crop—two years failed.

of a century. Table II shows the yield of nitrogen per acre, per annum, in wheat, in barley, and in root crops, each grown for many years in succession on the same land, either without any manure, or with only a complex mineral manure, that is supplying no nitrogen.

Bearing in mind what has been said as to the amount of combined nitrogen known to be annually deposited from the atmosphere, the figures in Table II have great interest and significance. Thus, over a period of thirty-two years, the wheat has yielded an average of 20·7 lbs. of nitrogen, per acre, per annum, without manure. But if we look at the quantities yielded during the first eight, the next twelve, and the last twelve years of that period, it is seen that there has been a gradual, but at the same time a considerable decline in the annual yield. From this it would appear probable that the nitrogen of the soil derived from previous accumulations, is being gradually reduced. Whether or not the whole of the excess of yield over that available from the rain, and other measured aqueous deposits from the atmosphere, is due to previous accumulations within the soil, and is therefore inducing a gradual exhaustion of its stock of nitrogen to that extent, we have not conclusive evidence to show. Determinations of nitrogen in samples of the soil taken at different times during the course of the experiments do, indeed, show an appreciable reduction. It is probable, however, that a part of the excess of yield is due to condensation of ammonia within the pores of the soil, beyond that which would be deposited in rain, and in the dew and other minor deposits condensed on the non-porous even surface of a rain-gauge, as already referred to.

Excluding the first eight years of the growth of wheat, it is seen that while over the next twenty-four years, 1852–1875, the wheat yielded 19·3 lbs. of nitrogen, per acre, per annum; the barley yielded an average of 18·3 lbs. over the same period. Again, during the first twelve of the twenty-four years, the wheat yielded 22·6 lbs., and the barley 22 lbs.; while, during the second twelve years, the yield in wheat was reduced to 15·9, and that in the barley to 14·6 lbs. The similarity in the yield of nitrogen over the same periods in these two closely allied crops, growing in different fields, is very striking, though, upon the whole, the indication is that the autumn-sown wheat has accumulated more than the spring-sown barley.

It is next to be observed that the annual use of a complex mineral manure has but very slightly increased the yield of nitrogen in either of these gramineous crops; and it is probable that the increased yield, such as it is, is derived from the previous accumulations within the soil, and not from atmospheric sources.

To sum up the evidence in regard to the sources of the nitrogen of these two typical gramineous plants, when none of it is supplied to them by manure, though it is not conclusively shown whence the whole of it is derived, it would at any rate appear probable, that it may be accounted for by the combined nitrogen coming down in rain and in the other measured aqueous deposits from the atmosphere, by the condensation of the ammonia of the air within the pores of the soil, and by the previous accumulations within the soil.

Let us now consider what is the yield of nitrogen by plants of other natural families, and first of all by certain so-called "root-crops"—turnips of the natural order Cruciferæ, and sugar beet of the order Chenopodiaceæ. On this point we have the experience of thirty-one years, excepting that during three of those years barley was grown without any manure in order to equalise the condition of the land as far as possible before re-arranging the manuring, and during two other years the turnips failed and there was no crop.

It should be premised that when root-crops are grown without manure of any kind, there is after a few years scarcely any produce at all; and hence the results recorded in the table are those obtained by the use of mineral manures, but without any supply of nitrogen. It is seen that during the first eight years of turnips, there was an average yield of 42 lbs. of nitrogen per acre, per annum. During the next three years barley yielded 24·3 lbs. annually. During the next fifteen years, thirteen with Swedish turnips, and two without any crop, there was a yield of 18·5 lbs. per acre annually. During the last five years sugar-beet yielded 13·1 lbs. per acre, per annum. Lastly, over the whole thirty-one years, during which there were three crops of barley, two years without any crop, twenty-one years of turnips, and five of sugar-beet, the average annual yield was 26·8 lbs. of nitrogen.

Here, then, we have a reduction to less than one-third during the later compared with the earlier years, and to a lower point than even with either wheat or barley; though, during the whole period, the annual yield is higher than with either of the two gramineous crops. It may be mentioned that we have other experimental evidence showing that the so-called "root-crops" exhaust at any rate the superficial layers of the soil of their available supplies of nitrogen, more completely than perhaps any other crop. It may further be added that the surface soil has shown during recent years a lower percentage of nitrogen than that of any of the other experimental fields. We have fair grounds for concluding, therefore, that if in the cases of the wheat and the barley the nitrogen yielded beyond that retained by the soil from the direct measurable aqueous deposits, together with that condensed within the pores of the soil from the atmosphere, be derived from previous accumulations within the soil, so also may the excess of yield by the so-called "root-crops" be accounted for.

We now come to the consideration of the yield of nitrogen when plants of the *leguminous* family are separately grown, or when they, and plants of some other families, are grown in alternation, or in association, with the Gramineæ. Table III shows the results obtained with beans, and with clover; with clover and barley grown in alternation; and with turnips, barley, clover or beans, and wheat, grown in an actual course of rotation.

TABLE III.—*Yield of Nitrogen per acre, per annum in Beans, in Red Clover, and in Rotation.*

Crops, &c.	Conditions of Manuring, &c.	Duration of Experiment.	Average Nitrogen per acre, per annum. lbs.
Beans	Unmanured	12 yrs. 1847-'58	48·1
		12 yrs. 1859-'70(*)	14·6
		24 yrs. 1847-'70	31·3
	Complex Mineral Manure	12 yrs. 1847-'58	61·5
		12 yrs. 1859-'70(*)	29·5
		24 yrs. 1847-'70	45·5
Clover	Unmanured	22 yrs. 1849-'70(†)	30·5
	Complex Mineral Manure	22 yrs. 1849-'70(†)	39·8
Barley	Unmanured	1 yr. 1873	37·3
Clover		1 yr. 1873	151·3
Barley	Unmanured — After Barley	1 yr. 1874	39·1
	Unmanured — After Clover	1 yr. 1874	69·4
	Barley after Clover more than after Barley		30·3
Rotation 7 Courses	1 Turnips 2 Barley 3 Clover or Beans 4 Wheat — Unmanured	28 yrs. 1848-'75	36·8
	1 Turnips 2 Barley 3 Clover or Beans 4 Wheat — Superphosphate	28 yrs. 1847-'75	45·2

Referring first to the results obtained with beans the table shows that without manure there was an annual yield over the first twelve years, 1847–1858, of 48·1 lbs. of nitrogen. Over the next twelve years, 1859–1870, it was reduced to 14·6 lbs. per acre, per annum. Still, over the whole period of twenty-four years, we have an annual yield of 31·3 lbs., or more than one and a half time as much as in either wheat or barley.

(*) Nine years Beans, one year Wheat, two years fallow.
(†) Six years Clover, one year Wheat, three years Barley, twelve years fallow.

In the case of wheat and barley it was seen that a mixed mineral manure increased the yield of nitrogen to a very small degree only. Not so in the case of the leguminous crop, beans. During the first twelve years a complex mineral manure, containing a large amount of potass—I call attention to this fact because we have abundant evidence that it is the potass chiefly that is effective—gave 61·5 lbs. of nitrogen per acre per annum against 48 1 lbs. obtained over the same period without manure. During the next twelve years, the potass manure gave 29·5 lbs. against scarcely half as much, or 14·6 lbs. without the potass manure. And finally, during the whole period of twenty-four years, the potass manure has given 45·5 lbs. of nitrogen per acre, per annum, against 31·3 lbs., or only about two-thirds as much, without manure; and we have more than twice as much yielded by a potass manure over a period of twenty-four years with beans than with either wheat or barley.

Before calling attention to the figures relating to another leguminous crop—red clover—it should be mentioned that leguminous crops generally are, and clover in particular is, extremely sensitive to adverse climatal circumstances; but clover is pre eminently sensitive to soil conditions also. Indeed, it is a fact well recognized in agriculture, that few soils can be relied upon to grow a good crop of clover oftener than once in about eight years; and many soils will not yield it so frequently. It will not excite surprise, therefore, that in attempting to grow clover year after year on the same land, we have only succeeded in getting any crops, and some of those poor ones, in six years over a period of twenty-two. Indeed, the plant failed seven times out of eight during the winter and spring succeeding the sowing of the seed; when, in some cases a crop of wheat or barley was taken, and in others the land was left fallow. Hence, over a period of twenty-two years we have had only six years of clover, one of wheat, three of barley, and twelve of fallow. Still, the annual yield of nitrogen over the twenty-two years was 30·5 lbs. without any manure, and 39·8 lbs., or nearly one third more, by mineral manure containing potass. Unfavorable as was this experiment in an agricultural point of view, still it is seen that the influence of the interpolation of this leguminous crop has greatly increased the yield of nitrogen compared with that obtained in either wheat or barley grown continuously; and that, unlike the result with those crops, a potass manure has here again, as with beans, greatly increased the yield.

Without attempting for the moment to discuss the probable source or sources of this greatly increased yield of nitrogen by leguminous as compared with gramineous crops, I will simply here remark in passing that we have no evidence leading to the conclusion that this increased assimilation is at the expense of the nitrogen existing at any rate in the upper layers of the soil. In fact, such initiative results as we have relating to the nitrogen in the soil of the experimental bean field, would rather lead to the conclusion that the better the crop has grown, and the more nitrogen it has assimilated, the richer rather than the poorer in nitrogen (as indicated by the soda-lime method) has the surface soil become. To this point, however. we shall have to recur presently; but in the meantime let us first refer to the yield of nitrogen in other cases in which leguminous crops have been interpolated with others.

It is, indeed, well known that the growth and removal of a highly nitrogenous leguminous crop is one of the best possible preparations for the growth of a gramineous corn crop, which characteristically requires nitrogenous manuring. A striking illustration of this apparent anomaly is afforded in the results next in order recorded in Table III.

After the growth of six corn crops in succession by artificial manures alone, barley was grown without manure in 1873 on one portion of the same land; and on another portion clover was grown. It is calculated that there were taken off in the barley 37·3 lbs. of nitrogen, and in the three cuttings of clover 151·3 lbs. Yet, in the next year, 1874, barley succeeding the barley gave 39·1 lbs., and barley succeeding the clover gave 69·4 lbs. of nitrogen; or 30·3 lbs. more after the removal of 151·3 lbs. in clover than after the removal of 37·3 lbs. in barley. Nor was this remarkable result to be explained by either accident or error. For, determinations of nitrogen in four separately taken samples of the soil, in the mixture of the four, and in the mixture of six others, taken from each plot, and at different depths, all concurred in showing an appreciably higher percentage of nitrogen, especially in the surface soil, nine inches deep, of the land from which the clover had been removed than in that from which the barley had been taken; and this was so, although, in every case, all visible vegetable debris had been carefully picked out. Here, then, the surface soil at any rate was positively enriched in nitrogen (determinable by soda-lime) by the growth and removal of a very highly nitrogenous crop. It may be mentioned that Dr. Voelcker has obtained results of a similar character.

The results next to be considered are those obtained in an actual four-course rotation of crops—namely, turnips, barley, clover or beans, and wheat. The experiments have been conducted through seven such courses; that is to say, over a period of twenty-eight years. One portion of the land, the results relating to which are given in the table, has been entirely unmanured during the whole of that period, and the other has received super-phosphate of lime alone, once every four years —that is to say, for the turnips commencing each course; but t has received no other manure throughout the twenty-eight years, either mineral or nitrogenous.

Under these conditions—that is with a turnip crop and a eguminous crop interpolated with two gramineous crops—we have, without manure of any kind, an average of 36·8 lbs. of nitrogen yielded per acre, per annum; or not far from twice as much as was obtained with either of those cereal crops, wheat or barley, grown consecutively. With super-phosphate of lime alone, which, in a striking degree increased the yield of nitrogen in the turnips, reduced it in the succeeding barley, increased t greatly in the leguminous crops, and slightly in the wheat mmediately following them, we have the average annual yield of nitrogen raised to 45·2 lbs. per acre, per annum, over the twenty-eight years; or to more than double that obtained by wheat or barley grown continuously by mineral manures alone. And it may be observed that where, in adjoining experiments, no leguminous crop was grown between the barley and the wheat, but the land was fallowed instead, the total yield of nitrogen in the rotation was very much less: the wheat succeeding the fallow yielding very little more nitogen than that succeeding the leguminous crops which had removed so much of it. In other words, the removal of the most highly nitrogenous crops of the rotation— beans or clover—has been succeeded by a growth of wheat, and assimilation of nitrogen by it, almost as great as when it has succeeded a year of fallow—that is to say, a period of accumulation from external sources, and no removal by crops.

One other illustration must be given of the power of plants of the leguminous and some other families to assimilate more nitrogen over a given area than those of the gramineous family. But before entering upon the bearing of the results in question on this particular point, it will be necessary to digress a little to call special attention to the conditions of the experiments under which the results were obtained; and it is the more desirable to do this, since the most important of Mr. Lawes' contributions to this Exhibition is an illustration of the results I am about to refer to.

Effects of manure.—I must here forestall a little what I shall have to refer to more fully further on, as to the effects of characteristically different substances on crops belonging to different botanical families. I will say briefly, then, that it is found that nitrogenous manures have generally a very striking effect in increasing the growth of gramineous crops grown separately on arable land, such as wheat, barley, or oats, all of which contain a comparatively small percentage of nitrogen, and, as has been illustrated, assimilate a comparatively small amount of it over a given area when none is supplied to them in manure. The highly nitrogenous leguminous crops, on the other hand, such as peas, beans, clover, and others, are by no means characteristically benefitted by the use of direct nitrogenous manures, such as ammonia-salts or nitrates, though nitrates act much more favorably than ammonia-salts. Again, while, under equal conditions of soil and seasons, mineral without nitrogenous manures increase comparatively little the poor-in-nitrogen gramineous crops that are grown separately, such manures, and especially potass-manures, as has been seen, increase in a striking degree, the growth of crops of the leguminous family grown separately, and coincidently the amount of nitrogen they assimilate over a given area.

Such, then, is the result obtained in the separate growth, on arable land, of individual plants of the different families. Now, in the mixed herbage of permanent grass land, we may have fifty, or even many more species growing together, representing nearly as many genera, and perhaps eighteen or twenty natural orders or families. Of these, the Gramineæ generally contribute the largest portion of the herbage; and, on good grass land, if the Leguminosæ do not come second, they are at any rate prominent. The degree in which other orders are represented may be very various indeed, according to soil, locality, season, and other circumstances. In Mr. Lawes' park, at Rothamsted, nearly eighty species have been observed; but of many only isolated specimens, and it may be stated generally that about fifty species are so prominent as to be found in a carefully averaged sample of the hay grown without manure.

Experiments on the influence of different manures on this mixed herbage were commenced in 1856: at which time the herbage was apparently pretty uniform over the whole area selected. About twenty plots, from one-quarter to one-half an acre each, were marked out, of which two have been left continuously without manure, and each of the others has received its own special manure, and as a rule the same description year after year—and the experiments have now been conducted over a period of twenty years.

Under this varied treatment, changes in the flora, so to speak, became apparent even in the first years of the experiments; and three times since their commencement, at intervals of five years—namely, in 1862, 1867, and 1872—a carefully averaged sample of the produce of each plot has been taken and submitted to careful botanical separation, and the percentage, *by weight*, of each species in the mixed herbage determined. Partial separations have also been made in other years.

Mr. Lawes has contributed a large case of specimens to the exhibition, which shows the botanical composition of the herb-ge on selected plots in the seventeenth season of the experiments (1872). The quantities of the different plants there exhibited represent the relative proportion, by weight, in which each species was found in the mixed produce of the different plots; and the whole illustrates in a striking manner he domination of one plant over another, under the influence of different manures, applied year after year on the same plot.

The general results of the experiments may be briefly summarized as follows:—

The mean produce of hay per acre per annum has ranged, on the different plots, from about twenty-three cwt. without manure to about sixty-four cwt. on the plot the most heavily manured.

The number of species found has generally been about fifty on the unmanured plots, and has been reduced to an average of only twenty, and has sometimes been less, on the most heavily manured plots.

Species belonging to the order *Gramineæ* have, on the average, contributed about sixty-eight per cent of the weight of the mixed herbage grown without manure; about sixty-five per cent of that grown by purely mineral manures (that is, without nitrogen); and about ninety-four per cent of that grown by the same mineral manures, with a large quantity of ammonia-salts in addition.

Species of the order *Leguminosæ* have, on the average, contributed about nine per cent of the produce without manure, about twenty per cent of that by purely mineral manures (containing potass), and less than 0·01 per cent of that by the mixture of the same mineral manures and a large quantity of ammoniacal salts.

Species belonging to various other orders have, on the average, contributed about twenty-three per cent of the produce without manure; about fifteen per cent of that by purely mineral manures, and only about six per cent of that by the mixture of the mineral manures and a large amount of ammonia-salts.

Not only the amounts of produce, but the number and description of the species developed, have varied very greatly between the extremes here quoted, according to the particular character or combination of manure employed, and to the character of the seasons, as is strikingly illustrated by the arrangement of the specimens in the case, which, however, it should be borne in mind, show the composition of the herbage on the selected plots in one particular season only—namely, in 1872.

Obviously, these few remarks can only very inadequately indicate the interest of these curious illustrations of the domination of one plant over another in the mixed herbage of permanent grass land. Nor do we pretend to be able to give a satisfactory explanation of the variations induced, founded on the obvious or recorded difference in above-ground or underground character or habit of growth of the individual species. The whole of the results—agricultural, chemical, and botanical—obtained during the twenty years of the experiments are, however, now in course of arrangement for publication; and that we may not overlook such explanations as might be suggested from the point of view of the botanist and vegetable physiologist, as well as that of the chemist, we have associated with ourselves Dr. Masters in working up the botanical part of the inquiry; and I think Dr. Masters will agree with me in saying that much more has yet to be known of the difference in the physiological capability, so to speak, of the leaves of plants of different species, genera, and orders, and of the difference in the distribution, and in the feeding power, of the roots, before satisfactory explanations of the facts observed can be given. Surely, a wide field of investigation for the botanist and vegetable physiologist is here opened up to view!

(To be continued.)

ART. III.—*Observations on a property of the Retina, first noticed by Tait;* by OGDEN N. ROOD, Professor of Physics in Columbia College.

IN the Edinburgh Proceedings, 1869–70, vii. p. 605–607, Tait described an interesting observation, which has perhaps some bearing on Thomas Young's theory of color. While suffering from indisposition, he noticed each time on awakening from a feverish sleep, that the flame of a lamp seen through a ground-glass shade, assumed a deep red color, the effect lasting about a second. He suggests that the nerve fibrils in the retina also partook of sleep, and on awakening the green and violet nerves resumed their function somewhat later than the red. I have in my own case noticed some instances, which seem to point out that after a *nervous shock*, sudden or prolonged, the green nerves (adopting the theory of Young,) recover their activity later than the red, and probably later than the violet nerves. The first observation was made twenty years ago while recovering from the effects of chloroform, which had been administered by a dentist, well known at that time in Munich. Upon regaining consciousness, and raising my eyes to the face of the operator, I was a little surprised at not having previously remarked his unusually ruddy complexion, but the next instant that this was due to an optical illusion, for his hair eared of a bright purplish-red hue. The singular appear-e lasted perhaps a couple of seconds, when his hair resumed ıatural color, which was *white*. This observation corresponds h that made by Tait.

give now an instance, where chronic effects of a similar racter were noticed by me for a couple of weeks continuously, ing convalescence from typhoid fever. In this case white ects appeared of a not very intense orange-yellow hue, the eral effect on a landscape being such as is produced by the nge-yellow rays of the setting sun. Here the activity of the en and violet nerves was diminished relatively to that of the . The auditory nerve was also evidently affected during same period, but precisely in what way I did not ascertain.

t is a matter of yearly observation with me, that effects, ilar in kind with those first noticed, are produced by pro-ged exposure to bright white light out of doors. Under h circumstances white objects no longer appear pure white, are tinted plainly purplish-red, and rather dull greens ıme a gray hue, as though all the green in them had been tralized, while strong greens are considerably reduced in usity (saturation.) Upon leaving the blinding glare and ering a darkened room, it often for several seconds appears d with a greenish haze.

wo of these cases and, probably that of Tait, point out, that apparatus for the reception of waves of light of medium gth, is more liable to be over-strained by nervous shocks or prolonged excitation, than is the case with those designed the reception of waves of greater or lesser length. Nervous angement and prolonged excitation, are then causes, which y produce temporary green color-blindness.

T. IV.—*On grains of Metallic Iron in Dolerytes from New Hampshire;* by GEORGE W. HAWES.

HE presence of metallic iron in certain basalts and dolerytes been repeatedly proved. It was first shown by Dr. drews that it was contained in the basalts of the Giant's iseway.[*] Reuss has proved its presence in Bohemian alts; and in this country it has been found in the Mesozoic erytes of New Jersey by Cook.[†]

n all these cases the iron has been detected by a microchem- method. If a portion of a rock is pulverized, and the magnetic constituents withdrawn by passing a magnet over the powder, any metallic iron which may be present in the rock can be recognized by treating this magnetic portion with an acid solution of sulphate of copper and then examining it with the microscope to see if any metallic copper is precipitated. If metallic iron is present it exchanges places with the copper, and crystalline aggregates of metallic copper, easily recognizable by their color and luster, will be seen. But as Dr. Andrews remarked in speaking of the Ovifak iron, in his inaugural address before the British Association last summer, it has never been found possible to detect with the microscope this iron which was known to be present. It is proposed here to point out the mode of occurrence of visible grains of metallic iron in dolerytes from New Hampshire.

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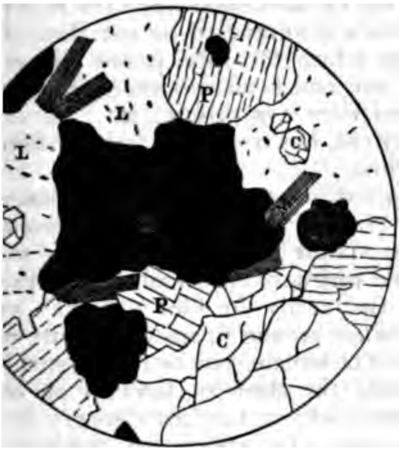
[*] Pogg. Ann., 1853, Bd. 88, p. 321.

[†] Cook, Annual Report of State Geol. Survey for 1874, p. 56.

Upon the Dry river, a small stream which gathers its waters from Mount Washington, there are numerous large dikes of chrysolitic doleryte, which cut through the old crystalline rocks. These dolerytes are composed of labradorite, pyroxene, chrysolite and magnetite, with a little mica; and, though they contain such decomposable materials, the rocks are remarkably fresh, and all the minerals are clear when looked at in thin sections with the microscope, showing no signs of alteration. This may be due in part to the remarkable compactness of the rock, and perhaps more to the great freshets in the spring time, which remove any soft or loose material.

Considering that the circumstances would be favorable for the preservation of metallic iron in these rocks if any were originally present, I tested for it according to the method before described, and the strength of the reaction was surprising. The magnetic constituents treated with sulphate of copper exhibited numerous bright crystalline aggregations of copper which were plainly visible to the naked eye. The reaction was so much more marked than any that I had obtained in testing the trap rocks of the Connecticut valley, which contain iron when not altered by decomposition, that I examined the sections to ascertain if it could not be seen under the microscope; and I found on shutting off the light from the mirror below and examining them with light reflected only from the section, that a few of the grains of magnetite possessed a bright metallic center, which had the luster of metallic iron, and which was very marked in the bluish-black magnetite. Taking an unmounted section which possessed one of these grains near its center, I treated it with sulphate of copper, when the grain was covered with a coat of copper, proving it to be iron. The following figure is drawn from a section of the rock, and represents it as magnified thirty five diameters. The black mineral is magnetite, and the light colored spot in arge grain is the metallic iron. The other minerals of the are as follows: The white mineral with no cleavage but with irregular fractures is chrysolite (C); the mineral showing an interrupted cleavage is pyroxene (P); the shaded mineral with a perfect cleavage is black mica (M); and the white mineral which is clear and shows only a few impurities is labradorite (L). The chrysolite and biotite show an attempt at regular crystallization, while the other ingredients do not possess any regular external form, the labradorite is finely striated by twinning, and this pros a beautiful effect when it is examined with polarized The magnetite is extremely magnetic, and, on being rated from the other material by a magnet, the grains retain netism and become little lodestones, and several quite grains can be drawn along together with the end of a num wire. These rocks form a part of the series that will escribed in the third part of the report of the New Hamp- Geological survey.



has been supposed that the metallic iron of basalts results the agency of carbon or some reducing agent, which act- on the magnetic iron at a high temperature has reduced a ion of it to the metallic state. The presence of this iron in enters of the irregular grains of magnetite seems to indi- that the magnetite in this rock may have resulted from xidation of the iron.

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V.—*On certain Phenomena of Binocular Vision;*[*] by FRANCIS E. NIPHER.

is possible that the phenomena here described may have observed before, but I have been unable to find any rd of them.

Fold a sheet of writing paper into a tube about an inch iameter. Look through the tube at some distant object with one eye, and toward the open hand with the other eye, the edge of the hand being in contact with the tube. The dissimilar objects producing unlike images upon the retinæ, the sensations blend and a hole will appear to be cut through the palm of the hand, through which the tube passes. That part of the tube between the eye and hand will appear to be transparent, as though the hand were seen through it.

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[*] Read before the St. Louis Academy of Science, Nov. 6th, 1876.

This experiment is very old, but seems not to have found its way into scientific literature.

2. Replace the hand by a sheet of unruled paper, upon which a drop of ink has been placed. By proper management, the ink blot may be made to appear within the tube, by so placing the paper that the hole which is apparently cut through it, coincides with the blot. Ordinarily the blot will then appear opaque, the paper immediately around it, and apparently within the tube, being invisible. The blot appears as it were suspended in space. By concentrating the attention strongly on objects seen through the tube, especially if they are strongly illuminated, the blot becomes more hazy, transparent, and may even be made to disappear altogether. The mental effort necessary to do this cannot be maintained more than a few seconds, and the spot will reappear. If the effort to cause the spot to thus disappear be kept up, the attention being strained to its highest pitch, the blot will disappear and reappear at regular intervals of a few seconds, the absolute time depending upon the illumination. It seems as though the organs exerted become fatigued, and relaxing for a few moments, refreshment sets in, which again renders possible the exertion necessary in causing the blot to disappear. It is possible that these experiments may be so made as to throw some light upon the conditions necessary in fixing the attention. Interesting experiments may also be made by substituting a fragment of a plane mirror for the sheet of paper. Looking through a rather large tube at a distant object with the right eye, and the reflected image of the left eye will appear staring up the tube, the adjoining parts of the head being invisible.

3. Substituting for the ink-blot a small hole cut through the paper, the small hole can also be made to appear within the tube, distinguishing itself by its different illumination, the surrounding paper being invisible, unless attention be directed too strongly to the paper in which the hole is cut. The relative illumination of the small hole, and the space immediately around it depends upon the relative illumination of objects upon which the tube is directed, and that of the sheet of paper exposed to the other eye.

4. Keeping the same arrangement, place at a distance of one foot from the end of the tube a sheet of paper so that objects

beyond it are still visible—arrange matters so that it is visible to the eye looking through the tube, but not to the other, directed at the small hole in the paper sheet. This second sheet will now appear to be traversed by a hole the same in size as that cut through sheet No. 1.

Cutting a small hole in sheet No. 2, matters are easily arranged so that it appears within the hole which was before seen within the tube. These experiments may be utilized in showing the simultaneous accommodation of the two eyes.

5. Tubes of this kind, blackened on the inside are very convenient in studying color sensations. Using two such tubes, look through one with the right eye, say, at red, through the other with the left eye at green paper, illuminated by the direct solar ray. The color sensations fade with marvelous quickness. Transferring both eyes to either color, say red, the eye fatigued by green sees the red greatly intensified, the effect being rendered the more striking by the simultaneous impressions received by the two eyes. Experiments in the combination of color sensations will readily suggest themselves.

The editor of the *Scientific American* has written something quite similar to some parts of this communication (Oct. 14), but a comparison of it with my short note in *Nature*, Aug. 10th, will show that I am not the borrower.

ART. VI.—*Notes on the Vespertine Strata of Virginia and West Virginia*; by WILLIAM M. FONTAINE.

Structure and geographical distribution.

THE eastern border of the unbroken area occupied by the Vespertine in the two Virginias may be taken as limited by the Main Allegbany, in the northern and middle portions of the area in question, and in the southern portion, by Peter's and East River Mountains.

As Prof. Wm. B. Rogers has shown, the rocks of the Vespertine, or No. X, compose the middle portion of the Main Alleghany from the Potomac to Pocahontas county. This range of mountains, for some distance south of the Potomac, is called "the Eastern Front Ridge of the Alleghany," while from the northern part of Pendleton county to the southeastern corner of Greenbrier county, it bears the name "Alleghany."

North of Pocahontas, according to Prof. Rogers, the range shows principally monoclinal westerly dips. The flexures here are comparatively broad and gentle. Hence the Vespertine and associated strata first dip gently westward, and then pass into a series of undulations, which extend nearly to the Ohio

River, declining more and more in abruptness. Owing to the increasing depth to which they are buried, the Vespertine strata are rarely brought to the surface in that direction by the flexures.

As we go south of Pocahontas the westward thrust which has affected this region, causes an increased elevation and flexing of the rocks. The structure of the Alleghany passes from monoclinal to anticlinal, with increasing steepness of dip, so that, in the vicinity of the White Sulphur Springs, where penetrated by the tunnel for the Chesapeake & Ohio Railroad, the strata stand nearly vertical.

Lower and lower rocks enter into its composition, in passing southward. As Rogers has shown, in the north, where monoclinal dips prevail, the lowest rocks seen in the east face of the mountain are those of No. IX or Catskill?. But near the White Sulphur, the core of the mountain is composed of the lowest Chemung, and, probably, Hamilton strata.

The development of an anticlinal structure, with increasing steepness of dip in passing southward, has had the effect of causing a belt of Vespertine rocks to be brought down on the east side of the mountain, and caught in a synclinal fold. This gives us the small coal beds seen near the Lewis Tunnel. At the same time the increase in the elevation and flexing of the strata southward from the northern part of Pocahontas county has brought up rocks lower than the Catskill?, not only in the Alleghany but over a belt about ten miles wide to the west, so that the east limit of the unbroken Vespertine, is thrown off to the western side of this area.

This belt shows strata all the way in the series, from the Oriskany to the Vespertine. The former barely appears in the lowest eroded places, and the latter shows merely small uneroded remnants of its lower portion. In the vicinity of the White Sulphur Springs, the strata throughout this area seem to be disposed in closed and contorted anticlinals overturned to the westward, which are separated by comparatively broad belts, in which the beds show moderately steep dips.

This disturbed belt is separated by a line of fault from the Vespertine strata. Here the transition is very abrupt, to a region which shows remarkably little disturbance. Prof. Rogers' description of the geology of the eastern corner of Monroe county would seem to show that the elevation of strata lower than the Vespertine in the Alleghany, and the belt to the west of it, is not maintained beyond the northeastern border of this county; for there we find that the eastern outcrop of the Vespertine area has closed in upon the Alleghany, while within the county this mountain chain is continued in Little Mountain, which is composed of upturned Vespertine strata.

With this disappearance of the elevated belt of disturbed Devonian strata, the fault which bounded it on the west also vanishes, but is succeeded by a much more important one, which begins some distance to the east of the termination of the Alleghany, in the northeastern edge of Monroe county. The rapid increase in the magnitude of this fault to the southwest soon swallows down the Devonian beds of the Alleghany, with their overlying bands of Vespertine coal beds. and brings the eastern outcrop of the Vespertine close to Lower Silurian strata. This fault, which runs not far to the west of Peters's and East River Mountains, bounds the Vespertine outcrop in that direction.

Every observer who has examined the structure of the country to the east and west of this fault, in the region extending from Monroe county to the southwest, has been struck with the remarkable difference in the amount of disturbance exhibited by the strata on the opposite sides of it. Prof. Lesley has given an excellent account of the condition of the country to the southeast of the fault above mentioned. The entire area here has been fractured, displaced, and folded, showing a truly astonishing amount of disturbance. On the northwest, or western side, we find the beds sometimes with their edges upturned, but they pass into an almost horizontal position in a short distance to the west. This is well shown in Prof. Lesley's section of Stone Mountain, where the conglomerate series is thus affected. Prof. Rogers, in his section of the strata in the northeast corner of Monroe county, gives a good example of this condition of things. Here the partially overturned beds of the Vespertine and Umbral, lying in the immediate vicinity of the fault, rapidly come down to nearly a horizontal position. In my account of the section near Greenbrier River, a similar structure will be shown. But here the line of fault separating the disturbed from the undisturbed region, is a minor one, developed by the rise of the Devonian belt near the White Sulphur Springs.

While the direction of this fault is thrown more in a northerly direction, and hence farther to the west than that of the one above described, yet it occupies the same relative position, and performs the same office, viz: that of checking the propagation of the disturbance through the strata to the west of it. This fault does not seem to continue far north, certainly not beyond Pocahontas county.

The country everywhere to the west of these last lines of fault, from Greenbrier county nearly to the Tennessee line, with the exception of a few undulations and disturbances in the vicinity of the fault, shows a prevailing northwest dip, as far as the Ohio River, which, as we go in that direction, brings us upon higher and higher strata. This region may then be regarded as an eroded plateau, sloping from the east toward the Ohio River. The mountains laid down as existing in this region are simply uneroded remnants of higher and softer strata, resting upon a basal plane, formed by lower and harder ones, such as the Lower Carboniferous Limestone, and the sandstones of the Conglomerate Series.

I have attempted to give some account of the topography of this part of the State of West Virginia, in the "Resources of West Virginia," recently published under the direction of the "State Board of Centennial managers."

North of Pocahontas county the flexures along the east border show no fault, but are propagated with diminishing force far to the west. In this quarter the most westerly fault is the great one, running along the west side of the great Lower Silurian limestone valley of Virginia. The Professors Rogers, in their discussion of the structure of the Appalachian Belt in the Virginias, have well shown the gradation of folds, in the northern part of the area in question, into faults in the southern part. In passing south the anticlinals become closed, then overturned to the west, and finally fractured. This feature is shown, as I have explained above, in the Devonian area near the White Sulphur.

An inspection of the map of the Virginias will show that the straight mountain chains which extend from the southern part of the two states in a northeasterly direction to the northeastern corner of Monroe county, are then thrown farther west, and made to take a north-northeasterly direction. The more southerly chains are produced by resistant strata, brought up along lines of fault, the more northerly, by folds.

The following seems to me to be the course of events, which resulted in the production of the present structure of the country:

The westward thrust, which, at the close of the Carboniferous Age, uplifted the Appalachian Belt, found the strata along its present western border, for some distance south of the Potomac, with their power of resistance comparatively unimpaired by any previously existing tension. Consequently, the undulations arising from the thrust were propagated far to the west. But to the south the case was different. The western edge was already weakened by the tension produced by the development of the deep trough, in which the lower Carboniferous strata were deposited, and this tension increased with the increased depth of this trough to the south. Hence, we find first the development of a minor fault along the eastern side of Greenbrier county, which relieved the strata to the west of it, in a great measure, from the westward thrust.

Passing south, into still more weakened strata, the sudden development of the great fault near the Sweet Springs, in Monroe county, to the east of the southerly prolongation of the Alleghany, in like manner relieves the country to the west from the upheaving force, causing the Alleghany, and the contorted belt on its west, to disappear, and the mountain chains to assume a more easterly course. From this point southward, in the region of greatest tension, the fractures are more profound and numerous. Any residual impulse, unrelieved by the faults, seems to have been exhausted in producing flexures in the immediate vicinity to the west of the fault, and in raising the eastern border of the great coal field as a whole, producing a gentle westerly dip toward the Ohio.

No doubt the great freedom of this area, thus tilted, from flexures of any magnitude, is due in part to the great development of massive sandstones in the lower Vespertine, and in the conglomerate series in this section, which would produce great rigidity.

A somewhat detailed explanation of the connection supposed to exist between the faulted and folded portions of the country, and the deep trough occupied by the lower strata of Carboniferous age, has been given in the above named "Resources of West Virginia," in the chapter by Mr. Maury on the "Coal Field of West Virginia."

The Vespertine strata occurring to the east of the limit mentioned at the beginning of this article, are found in detached belts and patches, mostly of small extent. As might be expected, from the above account of the structure of the country, in the northern and middle portions, they occupy usually the lower parts of synclinal folds, while in the southern portion, they are confined to the vicinity of faults. In each case they are more commonly found along the flank, or at the foot of a mountain, formed by the more resistant lower portion of the Vespertine, or underlying strata.

The following are the more important of these belts, and the only ones which I propose to notice, since they may be taken as true representatives of all the areas to be found in the region where they exist.

1. The belt mentioned above, as occurring on the east flank of the Alleghany Mountain, near the White Sulphur Springs. This belt contains the coal strata and plant impressions seen at Lewis Tunnel. It is especially instructive, since it shows the strata lying immediately above the Chemung, as well as the junction of these last with the lower portion of the Vespertine. All the strata here are well exposed in the deep cuttings for the Chesapeake & Ohio R. R.

This belt extends an unknown distance north of the railroad, probably to the northern part of Bath county. To the south, it terminates near the northeastern border of Monroe county. It occupies the bottom of a synclinal fold, and possesses but small width.

2. A much more extended and important belt, which lies about thirty miles east of the last. This commences in the northern part of Virginia, in the western part of Berkeley county, and extends thence south through the State, with some minor interruptions. It lies on the west side of the great Lower Silurian limestone valley, and close to the great fault which bounds it in that direction. In the northern and middle portions, the coal-bearing member of the Vespertine lies under the inverted massive sandstones of the lower member, and hence is found on the west side of the mountains, formed of this massive portion. In this part of the State, these mountains bear the names of "Great," and "Little," "North Mountain."

In the southern part of the State, the Vespertine strata are not inverted, but dip toward the fault. Hence in "Brush Mountain," the southern continuation of "North Mountain," the coal-bearing member lies on the southeastern face of the mountain. The great number of faults in this section has caused a small remnant to be caught and preserved, even within the area of the Silurian strata, as in the remarkable coal field of Price's Mountain, near Christiansburg in Montgomery county. I have been informed that coal has been discovered still farther to the east, within the limestone area, in the north end of Lick Mountain, in Wythe county. If this is true, it is without doubt Vespertine coal.

From the fact that all the strata, and the coals as well, thicken as we go east, it cannot be doubted that the Vespertine coal field extended considerably farther in that direction than any remnant now remaining. Leaving out of consideration the extension of these strata northward, into Pennsylvania, where they have been shown to contain coal beds, the area of the coal formation of this age, in Virginia and West Virginia, was by no means small. Judging only by the exposures which now remain, the belt of country over which well defined coal beds were formed, was more than 300 miles long, and fifty miles wide.

I have examined the exposures on the Greenbrier River, and at Lewis Tunnel, in the vicinity of the White Sulphur Springs, as well as those in the western edge of Augusta and Rockingham counties in Virginia, and in Montgomery county. I will give in the remainder of this article, some of the facts observed at these points.

The strata from the top of the Chemung to the base of the "Productive coals," in the two Virginias, pass into each other so gradually, that, in subdividing this great mass of sediment, one is forced to select the dividing planes somewhat arbitrarily, and to take for his guide, physical changes in the strata. The most natural horizon, to select as the upper boundary of the Vespertine in the Virginias, as it seems to me, is the base of the "Lewisburg," or "Lower Carboniferous Limestone." Yet, as we proceed north into Pennsylvania, this rock is absent. This is also the case in the eastern exposures in Virginia. Along the Greenbrier River there are certain red beds, underlying the limestone in question, and resting on the coal-bearing member of the Vespertine. Professor Wm. B. Rogers, if I understand his measurements correctly, places these in his Umbral, or No. XI, as he does the Lower Carboniferous Limestone, here exposed. There are two objections to this, I think. The physical character and composition of these red beds assign them more naturally to the Vespertine than to the limestone.

Another, and more important objection is, that if the lowest of these beds be made the base of the Umbral, then the great limestone formation must be considered as a subordinate member of the comparatively restricted Umbral series. For these reasons, I include the beds in question, in the Vespertine series. The Umbral series naturally begins at the top of the "Lewisburg," or "Lower Carboniferous Limestone," at least in the Virginias.

The Vespertine Strata on Greenbrier River.

Commencing at the fault above described, which occurs a little west of Caldwell Station, on the Chesapeake & Ohio R. R., and about six miles west of the White Sulphur, we find on the east side of the deep channel cut by a small stream, highly contorted, and overturned, strata of the Catskill?, while on the western side, and only 100 yards distant, the upper red beds of the Vespertine are seen dipping at an angle of only three or four degrees eastward, toward the contorted strata. These compose the base of the high hill there seen. The middle and upper portions of this hill are composed of the Lower Carboniferous limestone, into which the red strata pass gradually, by several alternations of red marlite and limestone. Passing west, along the railroad, the cuttings show that the red rocks rise gradually with a steepening easterly dip, until within 100 yards of the first exposure of the coal-bearing or middle member of the Vespertine, when they rise suddenly, at an angle of 45°.

These strata are composed almost entirely of deep red crumbling marlites. Some insignificant beds of flaggy, reddish, and gray sandstones, occur in the passage beds near the base of the limestone, and toward the middle of the series. Some of the thin flags at the top of the system show beautiful ripple marks. Toward the base, as we approach the coal-bearing member, the marlites are no longer of uniform red color, but are variegated with green and grayish splotches. The principal portion of the red strata much resembles some of the red shales of the supposed Catskill, which will be described farther on. The entire thickness is by estimate 250 feet.

This red upper member seems, from the measurements of Professor Rogers, to thin out to the north. As remarked above he puts it with the Lewisburg limestone, which is probably the equivalent of the St. Louis and Chester groups, in his Umbral series.

In his measurement of the Umbral in Greenbrier Mountain, near Huntersville in Pocahontas county, he puts fifty feet of red shales under the limestone. This point is thirty miles north of my section.

Still farther north, on the Potomac, near Westernport, Professor Rogers gives no red beds under the limestone, but shows that fifteen feet of red shales and sandstone occur about twenty feet from the base, which is composed of reddish and sandy gray limestone.

In the vicinity of the Greenbrier River, as above mentioned, the coal-bearing portion of the Vespertine rises boldly from beneath the red marlites, and forms cliffs of imposing height near the railroad bridge. These strata, however, do not attain a sufficient height to disclose the white sandstones and conglomerates, which form the lower member of the Vespertine in the two Virginias. Across the river they soon come down with a westerly dip, and disappear under the limestone to appear no more. This broad anticlinal seems to be the last important undulation affecting the strata in a westerly direction, for these maintain apparently a westerly dip nearly to the Ohio River.

In my article on the "Conglomerate series of West Virginia," published in the numbers of this Journal, for April and May, 1876, I have given some account of the geology of the country lying in that direction.

The middle member of the Vespertine as disclosed here, shows at its top, about seventy feet of rather siliceous, bluish gray sandstones, in thin beds, and of very firm texture. Under these occur about forty feet of thinly bedded, gray flags, which show throughout a curious distribution of carbonaceous matter. Fully fifty, pretty persistent, thin strings of carbonaceous material, are distributed over this space, being usually not more than an inch or so thick, but sometimes suddenly swelling out to the thickness of nearly a foot. No underclays exist, and all the material was plainly derived from drifted vegetation. This is also indicated by the frequent mixture of the carbon with the substance of the sandstones.

But while this portion of the field seems to have been under water, a portion of the neighboring area was in a condition to permit the development of a considerable coal bed. I have reliable information that some two and a half miles north of this point, and near the river, a coal bed exists at this horizon. At one time attempts were made to work it, but the coal proved to be too impure, and full of sulphur. It is locally about four feet thick. This is the coal bed mentioned by Professor Rogers, as existing on the river near Lewisburg.

Beneath the above mentioned carbonaceous portion, come 120 feet of firm gray, and brownish sandstones, and then forty feet of very flaggy, gray, soft sandstones and shales, with some layers of fissile black shale, containing indistinct vegetable impressions, mostly leaves of Lepidodendra. The lowest rock seen shows about twenty feet of dark gray, compact, fine grained sandstone, full of specks of pyrites, and containing in nests and pockets of yellow ochre poorly preserved impressions of shells. The entire thickness, here shown, of the middle member, is by estimate about 290 feet.

Professor Rogers shows that farther north, where the Vespertine forms a portion of the mass of the Alleghany Mountains, this member shows pretty much the same features, but that the amount of coal is much smaller, since it appears only in occasional thin strings of very small lateral extent.

Vespertine Strata near Lewis Tunnel.

Twelve miles east of the last mentioned locality we find the Vespertine rocks disposed in a narrow belt along the east side of the Alleghany Mountains. The Chesapeake & Ohio Railroad issues from this mountain, on the east side, in a deep cut made in Chemung strata, which dip about 75° southeast. Passing along the railroad eastward, we enter first the strata intermediate between the Chemung and Vespertine, which are probably Catskill, and after passing through these, see the lowest beds of the Vespertine, coming next in order. The dip flattens down rapidly in going east, until in the Vespertine strata it is not more than 25°.

The Chemung here is much like that of New York. Alternations of flaggy sandstones and shales, weathering olive brown in color, form the principal portion of the mass. Toward the top, rather massive, dull gray, and dingy brown sandstones occur, with some portions containing pebbles as large as a garden pea. Thin layers, crowded with impressions of shells, occur at intervals, being found even in the coarse sandstones. The highest strata showing Chemung fossils, are these coarse sandstones; succeeding them, the rocks show a decided change, and in this portion, the Catskill beds, if they exist at all here, must be found. The following is a section of them, with the thickness estimated in part. (1.) 120 feet of alternations of deep red marlites, and thick-bedded, rather argillaceous, reddish-brown sandstones. The sandstones and marlites are in about equal proportions. (2.) Seventy feet of dark red marlites, interstratified with ochreous sandstones of very argillaceous character, and showing balls and nests of brown hematite, arising from balls of pyrites. The sandstones when fresh are of dull brown color, but in weathering, assume yellowish-brown hues, in spots and patches. (3.) For 150 feet the ground is not well exposed, yet appears to be occupied by strata like the last, with a greater predominance of the sandstone. In (2), the marlites are confined to the lower portion next to (1). These three members, possessing a thickness of 340 feet, in which ferruginous matter abounds, are in all probability of Catskill age, but as they, so far as I know, contain no fossils, the question cannot be answered with certainty. These are succeeded by about 500 feet of flaggy sandstones, with interstratifications of shales, all when fresh dingy yellow, or brownish gray, but weathering to a dull brown color. These strata are of still more problematical age. As however in the eastern exposures, the Vespertine lower member seems to thicken at their expense, I include them with it. The junction of these beds with the lowest undoubted Vespertine strata, is here concealed by slides, as is partially, a considerable portion of their upper member.

Above the highest of these beds we have a decided change in the character of the deposits, and here I place the base of the Vespertine. This rock is a white, pebbly, highly siliceous sandstone, in the lowest portion seen. Its base is not exposed here. The pebbles are mostly small, but some of them attain the dimensions of half an inch. The great mass of the rock, especially the middle and upper portions, is a coarse sandstone of impure white color, becoming somewhat argillaceous at the top. The thickness seen was about sixty feet. This rock, it will be remembered, was not brought up at the place examined on Greenbrier River.

This is one of the most persistent and highly characteristic members of the Vespertine. Though always containing conglomerate bands, and marked by its siliceous character, it shows considerable changes in thickness, and the coarseness of its texture. Along the Greenbrier River the conglomerate portion, when exposed, often shows pebbles an inch in diameter. Professor Rogers mentions an exposure near Huntersville where the pebbles are even two inches in diameter.

Next above the sandstone member at Lewis Tunnel, we find he middle member as on the Greenbrier River, containing gray lags with coal. It is here fully exposed, and is by estimate about 350 feet thick.

The base is composed of forty feet of argillaceous, thick-bedded sandstones of a dull yellowish gray color, succeeded by twenty feet of firm olive colored sandstones. Some one or two thin films of coal occur in the first named, associated with black shale. The second stratum brings us to about the horizon of the lowest rocks seen on Greenbrier River. The succeeding strata here are in the main much like those west of the White Sulphur, being mainly gray flags. About fifty feet above the last mentioned stratum we find a true coal system, showing underclays with rootlets. The following is a section of it, beginning at the base:

1. Bluish-black, sandy shales, 5 feet.
2. Fire clay, 5 inches.
3. Coal, 8 inches.
4. Brown, flaggy sandstones, 3 feet.
5. Slaty coal, 6 inches.
6. Black shale, 12 inches.
7. Gray sandstone, 30 feet.
8. Fire clay, 12 inches.
9. Coal, 1–2 inches.
10. Fire clay, 5 feet.
11. Slaty coal, 5–6 inches.
12. Sandstone, 3 feet.
13. Black sandy slate, 15 ft.

No. 7 contains films and streaks of coal from floated vegetable matter. No. 10 is full of Pinnularia rootlets. No. 13 shows plainly the marks of considerable erosion of the underlying beds. It is charged with carbonaceous matter, and contains films and fragments of coal. Indeed there are evident signs that several of the small coal beds suffered considerably from erosion, before the deposition of the overlying strata. The lower part of No. 13, for some four or five feet, contains large angular fragments of No. 1, mixed with others from the underlying Devonian brown sandstones. Some of the fragments are three or four inches in diameter. With the exception of No. 1, all the black shales of the section seem to be composed of material derived from the red and brown Devonian strata. On losing by weathering the carbon to which they owe their black color, they assume reddish and brown hues.

The coals are really two in number, disposed in an upper and lower double bed, about thirty feet apart, which accords well with their distribution throughout the Vespertine coal field. The material is very impure, slaty and full of sulphur.

Over No. 13 we find about seventy-five feet of firm siliceous, rather coarse, bluish-gray sandstones, containing fragments of the lower coal-bearing rocks, with drifted stems and pieces of coal. Lewis Tunnel is cut in these rocks.

Over this we have twenty feet of gray sandstone of firm texture, graduating into ten feet of firm thin bedded shales, black when fresh, but weathering brown. This last contains the small coal bed at the entrance to Lewis Tunnel, and has afforded all the plant impressions found there. The coal is quite local, and has been found nowhere else so far as I know. This horizon however, in other places, often yields abundant plant impressions.

At the top we have some alternations of dark shales, with olive, and reddish marlites for thirty feet, and finally red marlites. No limestone was seen above the red marlites. The conditions here indicate a quieter deposition of sediment than that which took place near Greenbrier River, for there the firm gray flags are succeeded abruptly by the marlites. The uppermost coal bed here exposed is, at its thickest, about twelve inches, but soon passes into shale.

We find from the above data that in this section the Vespertine strata may be divided into three members.

1. A lower member, characterized by siliceous sandstones and conglomerates. Thickness exposed, sixty feet. With this should probably be counted 500 feet of underlying, more argillaceous flags, giving a total of 560 feet.

2. A middle member, characterized by the predominance of gray sandstones containing coal. Thickness, about 350 feet.

3. An upper member, consisting almost entirely of red marlites, and having a thickness of about 250 feet. This would give the entire group a thickness of 1,160 feet.

It will be seen that, as the base of the lower member is nowhere exposed in this region, sixty feet cannot be taken as its entire thickness. I am of the opinion that it is considerably greater. Professor Rogers, in his descriptions of the Vespertine, nowhere gives any descriptive section of the strata, so that we are left in doubt as to what stratum he assumes as its base. It is plain that he does not include the red overlying strata in it; this makes it difficult to use his measurements, as a basis for comparison. He gives the thickness on the Potomac near Westernport, as only 200 feet, while near Lewisburg he says it has increased to 800 feet. This seems in any event, to establish the fact of a considerable thickening to the south.

[To be continued.]

:T. VII.—*On the production of Transparent Metallic Films by he Electrical Discharge in exhausted tubes; by* ARTHUR W. WRIGHT, Professor of Molecular Physics and Chemistry, Yale College.

THE spectra of gases contained in vacuum-tubes, which have
:n prepared by the use of the mercury pump, usually exhibit
es caused by the presence of the vapor of this metal. In
ne cases this is no disadvantage, since they serve as conven-
t reference points in fixing the position of the other lines or
ıds observed. As the mercury vapor is naturally an excel-
t conductor of electricity, however, there is often reason to
pect that its presence may affect the character of the discharge
newhat, and its removal becomes desirable. In some recent
)eriments by the writer this end was obtained by placing in
:h tube a few pieces of clean gold foil loosely rolled into
all pellets. As this metal is readily amalgamated it will,
er a time, take up the mercury vapor, causing the disap-
ırance of its characteristic lines from the spectrum. A still
ter method is to wrap a small piece of the foil about the
l of the electrode, or to attach to it a short gold wire. The
d will be volatilized and deposited upon the walls of the
e in a very thin layer, thus exposing a much larger surface
the action of the mercury vapor, in the manner described
ow.

n some of these experiments the tube under examination
s so placed that the gold lay at the bottom of the upper
tion, at the point where the capillary part is attached. In
s position it was exposed to the action of the more intense
charge through the narrow part, and after a time it was
nd that a lustrous and coherent film was deposited upon the
ss, the gold having evidently been volatilized by the elec-
ity and condensed upon the walls of the tube. In order to
dy more conveniently the conditions under which the best
cts might be produced, a loose roll of the foil was placed in
middle of a tube about five millimeters in caliber, having a
ınch near one end for the purpose of withdrawing the air,
l with platinum electrodes inserted into the ends. This was
ıausted until a discharge from an induction coil passed read-
, when it was found that the gold was speedily deposited
n the tube as before, and by shaking the foil along, a con-
erable area was covered with it in a short time. It appeared,
n under the microscope, as a perfectly continuous film,
ming a brilliant mirror, and showing the characteristic green

color by transmitted light very beautifully. When the tube was afterwards rather strongly heated the gold lost its mirror-like surface in the thinner parts, assuming a frosted appearance, and the light passed through it had a fine ruby color, conforming in this to what was observed by Faraday in his experiments on the relation of metals to light.* A singularity in the result was the fact that the volatilization occurred only at that end of the foil which was made a negative pole. This was observed to be the case in all the subsequent experiments, except that in one or two instances where a powerful discharge had been maintained for a considerable time a very slight deposit was observed at the positive end also.

As the matter appeared to be of interest with respect to its furnishing a new method of producing transparent metallic films, the investigation was extended to a considerable number of metals. Various forms of tubes were employed in successive trials, but the method found most advantageous was the following: clean tubes of white glass, about fifteen centimeters in length, and with a caliber of from four to six millimeters, were provided in the middle with a small branch tube for attachment to the pump. In the ends were placed the electrodes formed of the metals to be examined. These were generally in the form of thin wires from one-fourth to one-half a millimeter in thickness. About one centimeter of this was enclosed in a thin glass tube about three centimeters long, drawn out of the same piece as the main tube, and made so fine at the end as just to receive the wire. A platinum wire was placed in the other end, so as to touch the first wire, and sealed in. This was then carefully sealed into the end of the main tube, the electrode being in its axis, and the platinum wire projecting. It was necessary to cover the latter thus in the interior to prevent its giving a deposit upon the tube with the metal under examination. The tube was now exhausted to a tension of one or two millimeters, or so far that, when the discharge from the induction coil was passed through it, the glow surrounding the negative pole filled the tube along the whole extent of the electrode. After the coil had been put in operation for a few minutes a deposit was formed upon the glass, appearing at first as a mere darkening or discoloration, which, gradually becoming deeper, finally began to show metallic luster, while still suffering the light to pass freely. In almost all cases it covered the whole area of the glass opposite the electrode, but did not extend much beyond it. After the film was sufficiently developed the small branch was closed with a gas flame, the tube drawn off, and sealed.

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* Experimental Researches in Chemistry and Physics.

For metals readily oxidized it was necessary to fill the tubes with some gas which would not act upon the deposit formed, as otherwise it was impossible to obtain good results. In these cases the air was first thoroughly removed, the tube filled with pure dry hydrogen, and then exhausted. In a few cases the tubes were refilled with hydrogen several times to ensure the complete removal of the oxygen. The perfection of the film was found to depend also in some measure upon the steadiness of the electrical action, and the proper regulation of the power of the current used. When the Holtz machine was employed as a source of electricity no effect was obtained without condensers, and with them the discharge, at least with the tension of gas used, did not occur in such a manner as to yield good results. The trifling deposit obtained in this way was opposite the positive electrode. Possibly by exhausting the tubes so as to reach a much lower tension the electro-machine might be made available, but the induction coil is both efficient and convenient.

With a gold wire one-third of a millimeter in diameter and four centimeters long, an exquisitely beautiful deposit was formed over a space a little longer than the wire. The first noticeable effect was a slight discoloration of the tube by the deposited metal, while it was still too thin to show the metallic luster by reflected light. The tint was pinkish, inclining to violet, resembling that at the more refrangible end of the spectrum. As the film increased, the tint passed through blue, bluish-green, and finally, when of sufficient thickness, it appeared a clear, brilliant green, slightly inclining to bluish-green. By reflected light the film has a splendid luster, and the full golden color. It thins out gradually at the extremities, and becomes imperceptible at a point five or six millimeters from the end of the wire, with the same gradation of tints as was observed in its formation. The metallic reflection fades out in a similar manner, but ceases before the coloration.

With silver wire of about the same dimensions, the coating upon the tube was scarcely less beautiful and perfect. The full luster was developed gradually, and the light transmitted by the completed film is a pure, deep blue. Copper gives a fine lustrous mirror, appearing dull green by transmitted light. It is volatilized with more difficulty than the preceding metals. Bismuth on the other hand is obtained in a thin film with extreme ease, a battery of three small Grove cells with a coil giving a half inch spark producing the desired result in two or three minutes. The film is very transparent, and has a color such as would be produced by mixing a clear blue with a pure gray or neutral tint. The metallic layer is remarkably uniform, and of great beauty, possessing a brilliant luster by reflected light.

Platinum is volatilized with comparative ease, especially in a narrow tube. Its deposition on the glass in this way is a familiar occurrence, as few of the common vacuum-tubes which have been subjected to the action of the induction coil for a long time fail to show the effect. In a small tube the layer is very bright, and is easily made thick enough to be quite opaque. When sufficiently thin, it transmits light of a gray color, with a slight bluish tinge. Palladium also is deposited in a thin layer without difficulty, and appears of a smoky brown color by transmitted light. Lead forms a very even film, with the characteristic color of the metal, though it has but a comparatively feeble luster. It has a high degree of transparency, appearing of a smoky-brown color, inclining to an olive tint when very thin. Thorough exclusion of the oxygen and vapor of water is necessary to the successful formation and preservation of the film, as when exposed to the air or moisture it is destroyed by oxidation in a very few minutes.

Zinc and cadmium yielded brilliant mirrors, with a white, silvery luster, and appearing deep grayish-blue by transmitted light, with a barely noticeable inclination to purple. It is less deep in tint than the light passed through silver, but deeper than that from bismuth. There was no perceptible difference between the two metals, unless it were a slightly greater intensity of the coloration in the case of the zinc.

Aluminum was volatilized with considerable difficulty, requiring five or six cells and a powerful coil. It formed a mirror-like film, which by transmitted light had a brownish color, but the result was not entirely satisfactory. Magnesium yielded even less readily, and showed no effect at all when tried with the means which had given good results in the other cases. It was necessary to reduce the electrode to a very fine wire, and this was enclosed in a tube of only 3·5 millimeters caliber. The larger coil was used, and the power of the battery gradually increased to six Grove cells. Not the slightest effect was produced when a smaller number was employed, but after the application of this power for a few minutes, the electrode was suddenly surrounded by a burst of green light, and the deposit was formed almost instantly upon the glass. It had a brilliant luster, and when the light was seen through it, a grayish-blue color similar to that of zinc or cadmium, but less clear.

Tin did not give very satisfactory results, as when the electrode was made small enough for the purpose it was difficult to avoid fusing it. The film when obtained was not as fine as those produced with the other metals mentioned, but had in some parts a silvery metallic luster, and was sufficient to show that when seen by transmitted light the metal appears of a brownish gray or sepia tint.

Interesting results were obtained with iron, which gave a very beautiful and perfect film, having a brilliant luster, and a high degree of transparency. The light transmitted by it is very nearly of a pure neutral tint, though with a faint tinge of brownish. The electrode was a wire 0·3 millimeter in diameter. This was carefully cleaned, and the tube filled with dry hydrogen three times before the final exhaustion. Without this precaution it is impossible to obtain reliable results, as the metal is partially oxidized, and the film not only stained, but its color by transmitted light changed to brown, or even to deep orange-yellow. This was the color exhibited by the film obtained in the first trial, in which the tube was filled with air. Externally it exhibited a vivid iridescence, in various colors, but at the extremities of the deposit the metal had its proper luster. Subsequent trials in which the tube was once filled with hydrogen gave better results, but the yellow tint and the iridescence did not disappear until the thorough removal of the oxygen and moisture, as described.

For those metals which are not readily obtained in the form of thin wires, a modification of the process was employed, as follows: a tube open upon one side was made by softening the end of a glass tube in a gas flame and drawing out one edge with another piece of glass. A trough was thus formed, at first shallow but growing deeper and deeper as the whole edge began to be drawn upon, and by properly adjusting the heat applied, it could be made as fine as desired. A tube of this kind from half a millimeter to a millimeter in diameter with a platinum wire inserted in the closed end, and with the open end evenly and firmly packed with filings or powder of the substance to be examined formed the electrode, which was used in the ordinary way.

Nickel and cobalt were experimented upon by this method, and films obtained, but as the removal of the oxygen was not sufficiently complete they were less perfect than those produced from the other metals, though sufficient to show that the color by transmitted light is gray or brownish gray. Tellurium employed in the same way afforded a very brilliant layer, which gave to the light seen through it a dull purple color.

At the suggestion of Prof. Dana an experiment was made with magnetic oxide of iron, native magnetite in powder being employed with one of the small troughs. It was volatilized with difficulty, but apparently without decomposition, and formed a somewhat lustrous film, appearing gray-brown by transmitted light. The result is of interest with reference to the occurrence of thin, somewhat transparent layers of this substance in certain micas, where it has the same color as that observed in this experiment.

In Faraday's experiments deposits of several different metals upon plates of glass or other materials were obtained by passing the spark from a Leyden battery between the points of wires near the plates in an atmosphere of hydrogen. Films so obtained are more or less irregular, and he describes them as apparently not entirely continuous. Those formed by the method here described, however, are generally very uniform and coherent, and even under the microscope appear to be perfectly continuous. For a study of the optical properties of the metals they can be formed upon narrow slips of plane glass introduced into the tubes by the side of the electrode. Simple examination of the tubes with a Nicol's prism shows that these films, at least in the case of gold, silver, iron, zinc and cadmium, which have been tried by the writer, polarize the light transmitted by them powerfully, and the degree of polarization appears to increase with the incident angle as far as observation can be conveniently carried, which implies a very high refractive index. It might be expected that the light should be elliptically polarized, but this point was not determined, and the optical properties of the films remain for further study.

With respect to the relative energy of electrical action necessary to volatilize the different metals the observations were hardly precise enough to warrant the statement of a definite law. Bismuth was volatilized most readily of all, gold and silver with but slightly less facility. Platinum, palladium, lead, tin, zinc and cadmium yield less readily, while copper, iron, nickel and cobalt require a rather intense discharge and are volatilized with some difficulty. Aluminum requires an energetic electrical action exerted for a long time, and the electrode must be a quite fine wire. Magnesium is acted upon still less readily, and is by far the most difficult, of all the metals tried, to be obtained in the state of a thin layer. Success was attained by the use of an energetic battery of five or six Grove cells, with a coil capable of giving two-inch sparks, the electrode being a wire cut from a thin ribbon of the metal and not more than one-fifth of a millimeter in thickness. Even then no effect was produced till this was enclosed in a very narrow tube by which the electrical action was concentrated. The electrode itself appeared bright green, showing that the discharge did act upon the metal, forming a thin envelope of vapor about it, which did not reach the glass however until the power of the current was increased and the size of the tube considerably diminished. It will be seen that the heavy metals, that is, those with high atomic weights, are most readily volatilized, while those with smaller atomic weights oppose great resistance to the electrical action, and those with medium weights occupy an intermediate position; but the fusibility, tenacity, and electrical conductivity also appear to exert some influence as to the place of the different metals in the list.

It may be observed also that where it is desirable to avoid discoloration of vacuum-tubes by the metallic deposit, this can be effected by making the electrode within the tube of aluminum or magnesium, the interior portion of the platinum wire which passes through the glass being itself covered with a small glass tube. Of the two metals magnesium is the best, as a wire half a millimeter in diameter would not be at all affected by discharges of the intensity ordinarily used with vacuum-tubes, nor would it be so easily fused or rendered red hot as a wire of platinum. Of course these metals could only be used with gases which would have no chemical action upon them.

Yale College, December 13, 1876.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the so-called Crystallized Boron.*—Hampe has prepared and submitted to careful examination both of the forms of the so-called crystallized boron, the black and the yellow, and finds that neither is pure boron, both being compounds of this substance. For the preparation of the black variety, 200 to 400 grams of fused coarsely pulverized boric acid was placed in an English clay crucible, a piece of aluminum weighing 100 to 200 grams was laid upon it and covered with boric acid, and then the cover of the crucible was luted on with clay. The whole was enclosed in a Hessian crucible, the space between the two being filled with quartz sand. The secret of the production of the black crystals consists in the absence of carbon in the crucible. The fusion was effected in a melting furnace, the fuel used being coke, and the time of heating three hours. By closing the draft almost completely, the cooling took place very slowly, requiring from 12 to 18 hours; the crystals being increased in size proportionally. On breaking the inner crucible when cold, the upper layer of the fused mass was glassy and consisted of aluminum borate. Within this was a thin dense very hard layer of pure alumina, which surrounded the regulus. The free surface of the metal as well as the cavities in it were covered with magnificent black crystals, which were obtained on solution of the aluminum, accompanied by red hexagonal plates of the aluminum boride of Wöhler and chocolate-brown crystals of silicon. The yield was small, only 2·5 to 3 grams being obtained from 100 grams aluminum, one gram of which proved completely pure. Various other methods of preparation were tried; but the yield was less in every case. The crystals are monoclinic prisms, have a brilliant metallic luster,

are black in thick but dark red in thin layers, become blued like steel when heated in the air though not combustible when heated in a stream of oxygen. Their hardness is between 9 and 10, their density 2·5345. Concentrated hot nitric acid dissolves them slowly, fused potash and lead chromate rapidly. On analysis they yielded 17·30 per cent of aluminum and 82·70 per cent of boron, corresponding to the formula AlB_{12}. The yellow quadratic crystals were obtained by effecting the fusion in carbon crucibles; one melting, which was on a large scale, yielding 5·528 grams pure crystals, on some of which the octahedral edges were 4 mm. long. They are honey-yellow in color, very brittle, harder than corundum and nearly as hard as the diamond, and have a density of 2·615. On analysis they gave as a mean: Aluminum 13·15, iron 0·24, copper 0·04, carbon 3·76, boron (by difference) 82·81; corresponding to the formula $C_2Al_3B_{48}$. All attempts to prepare pure boron crystallized were fruitless. The author is now examining the so-called amorphous boron in this direction.—*Liebig's Annalen*, clxxxiii, 75, Oct., 1876. G. F. B.

2. *On the Constitution of the Phosphates.*—Berthelot and Louguinine have made a thermic research on phosphoric acid with a view to determine its basicity. They studied the heat-changes characterizing the union of this acid with two widely different bases, ammonia and baryta, and those produced by water and by various acids of different energy upon the three classes of phosphates. To these, they added alkalimetrical evidence. The conclusion which they reach is that the three equivalents of base, successively united to phosphoric acid, are thus united with very different values; the first equivalent being comparable to that of the nitrates or alkali chlorides, the second to that of the carbonates and borates, and the third to that of the alkali alcoholates. When for example, phosphoric acid and soda unite, the union of the first equivalent of the base evolves 14·7 calories, the second 11·6 calories and the third 7·3 calories; while in the case of a true tribasic acid like citric, the quantity of heat is constant for each equivalent. being in this case 12·7 calories. In the case of ammonia, no heat at all is evolved on adding the third equivalent, and hence no triammonium phosphate exists. In view of the results obtained, the authors say that phosphoric acid cannot be a tribasic acid, at least in the same sense as citric acid, the third equivalent of base being separated even by dilution; nor can it be a dibasic acid like sulphuric, oxalic, or tartaric acid, since the second equivalent of base is not neutralized by the acid and is entirely separable by hydrochloric and nitric acids and even partially by acetic. Hence they regard it as an example in inorganic chemistry of what in organic chemistry are called monobasic acids with a mixed function.—*Ann. Chim. Phys.*, V, ix, 33, Sept., 1876. G. F. B.

3. *On the Critical Point of Liquid Carbon Dioxide.*—Hartley has made further examinations of the liquid enclosures in minerals and has determined with care the critical point of temperature

for a large number of those composed of liquid carbon dioxide. Curiously enough this point was found to vary considerably: In topaz, in three specimens, the critical point was 28·5°, 26·5° to 28°, and 27·5° to 27·6° C.; in two specimens of tourmaline, from America, it was 27·27° and 26·9°; in five quartz specimens, it was 30·95°, 30·95°, 32·5°, 33·7° and 29°; in a beryl from Lurat, it was 30·92°; in three oriental sapphires, 30·5° to 31°, 25·5° to 26°, and 29·5°. The author explains this lowering of the critical point by the fact observed by Andrews that this effect is produced by the presence of an incondensable gas, perhaps nitrogen. The raising of the critical point appears to him to be due to hydrochloric acid gas. The facts observed seem to the author to have a bearing on the question of the formation of some of these minerals, and he suggests that corundum may have been formed by the action of aluminum chloride or fluoride upon calcium carbonate, producing alumina and carbon dioxide; the latter being condensed, would form cavities in the alumina crystals and would liquefy on cooling. If the reaction were dry, the cavity would contain only the dioxide; but if moisture were present, it would contain water also. With reference to the diamond, he suggests that it may have been formed by the action of reducing agents upon very highly compressed carbon dioxide at temperatures above its critical point. —*J. Chem. Soc*, xxx, 237, Sept., 1876. G. F. B.

4. *On the Spectra of Indium.*—CLAYDEN and HEYCOCK while observing the spark spectra of the metals, in the Cavendish Laboratory, Cambridge, noticed that instead of the three lines which are ordinarily supposed to constitute the spectrum of indium, the spark spectrum really contained sixteen. The wave-lengths of the three lines are given by Thalén as 4532, 4509 and 4101 tenth-meters. The second and third only of these lines are visible in the spark-spectrum. The wave-lengths of the sixteen lines the authors give as follows: 6906, 6193, 6114, 6095, 5922, 5905, 5862, 5820, 5722, 5644, 5250, 4680, 4656, 4638, 4510, and 4101 tenth-meters. The first of these lines is remarkable for its low refrangibility, only potassium, strontium and antimony giving lower ones. The wave-lengths were not measured directly apparently, but obtained by interpolation from the scale of the four-prism spectroscope with which the measurements were made.—*Phil. Mag.*, V, ii, 387, Nov., 1876. G. F. B.

5. *On the Preparation of Hydroquinone.*—WESELSKY and SCHULER have discovered a new and comparatively simple method of preparing the diatomic phenol of the ortho or 1:2 series, hydroquinone. If nitrous acid vapors be conducted into a cooled etherial solution of phenol, the mass is filled in a short time with crystals of diazophenol nitrate. This salt dissolved in dilute sulphuric acid (one of acid and two of water) mixed with alcohol and ether added, becomes sulphate which by precipitating with barium chloride can be easily be converted into chloride. These salts are identical with those prepared by Schmitt from the non-volatile mononitrophenol of fusing point 110°. If now an

aqueous solution of one of the above salts, preferably the sulphate, containing 10 to 15 per cent of concentrated sulphuric acid, be boiled till its color changes to a dark red, and, afterward be extracted with ether, the ether leaves on evaporation crystalline masses which on sublimation give colorless needles, which dissolved with water and treated with ferric chloride, yielded magnificent green needles having a metallic luster. This substance is hydroquinone and the yield is 46·2 per cent, the theoretical being 50.—*Ber. Berl. Chem. Ges.*, ix, 1159, Sept., 1876.

G. F. B.

6. *On Gelsemium sempervirens.*—SONNENSCHEIN has examined the root of the wild jasmine and has isolated its alkaloid, gelsemine, to which he gives the formula $C_{11}H_{19}NO_2$. The substance called by Wormley gelseminic acid, he finds to be esculin.—*Ber. Berl. Chem. Ges.*, ix, 1182, Sept, 1876. G. F. B.

7. *Kurze allgemeine Einleitung zu den aromatischen Nitro-verbindungen* von PETER TOWNSEND AUSTEN. Pamphlet, 43 pages. Leipzig: Winter, 1876.—This little work possesses a peculiar interest, as it is the attempt of an American to produce a comprehensive treatise in a foreign language and country. The manner in which Dr. Austen has treated this class of organic compounds differs greatly from the general style of monographs, and is certainly practical and original. The work is intended to afford all necessary data to those working on researches involving the nitro-compounds. The arrangement is such that the facts sought for can readily be found. The style of the book is clear and remarkably concise.

There is no doubt but that similar treatises on various other groups of organic compounds, such as the hydroxyl, amids, and many others, would enormously facilitate the labors of chemists engaged on original research.

The book is dedicated to Prof. A. W. Hofmann, of Berlin.

8. *Mariotte's Law.*—Prof. MENDELÉEFF, at the Warsaw meeting of Russian naturalists, described the results of researches he has pursued during 1875 and 1876, for the verification of Mariotte's law. His former researches had proved that the decrease of volume of the permanent gases proceeds at a slower rate than the increase of pressure exerted on them, if the pressure is less or much greater than the mean pressure of the atmosphere. The experiments of Regnault, made with air, nitrogen, etc., at pressures higher than that of the atmosphere proved, however, directly the contrary, and a series of measurements undertaken some years ago by Prof. Mendeléeff to verify those of Regnault, gave the same results. Suspecting that there might be some cause of error affecting in the same way both series of experiments, Prof. Mendeléeff and Mr. Bogussky constructed special apparatus eliminating all possible causes of errors and allowing the most perfect accuracy of measurements. With these they made a new series of researches, at pressures varying from 700 to 2,200 millimeters. These researches confirmed again the conclusions of Regnault,

showing only numerical differences in the values obtained, and proving, for instance, for the air, that its deviations from Mariotte's law are even less than appeared before. But the most important results of the researches is that the divergences from Mariotte's law shown by the air being negative at pressure above the mean atmosphere, as was observed by Regnault, proved to be positive (decrease of volume slower than the increase of pressure) at pressures below it. We must then conclude that the air experiences a change of compressibility at a certain pressure above the mean of that of the atmosphere; and this conclusion is supported by the circumstance that such a change was noticed also in the carbonic and sulphurous acid gases, but at pressures far lower than is the case for air. Only for hydrogen the divergence is of the positive kind at all pressures. Altogether we must conclude that the deviations from Mariotte's law are far more complicated than has been suspected.—*Nature*, xv, 70. E. C. P.

9. *Physical Properties of Gallium.*—M. LECOQ DE BOISBAUDRAN has recently prepared more than half a gram of pure gallium. In the liquid state this metal is of a beautiful silvery whiteness; but in crystallizing it assumes a very pronounced bluish tinge, and its luster notably diminishes. Isolated crystals may be obtained which are based octahedra. The melting point was found to be 30°·15, which was unaltered after remaining for two hours in boiling water. It was therefore certainly free from potassium. It was next kept for half an hour in nitric acid diluted with its volume of water. The loss amounted to only a fraction of a milligram, and the point of fusion remained unaltered. The calculation of M. Mendeléeff for a hypothetic substance which seems to correspond to gallium, at least in several of its properties, conducted to the number 5·9. The first measurement with 6 centigrams gave a density of 4·7 at 15°. Later observations gave the higher results of 5·5 to 6·2. Finally, a measurement with 58 centigrams gave, in two experiments, 5·90 and 5·97. The same gallium was afterwards kept during half an hour between 60° and 70° in nitric acid diluted with its volume of water, washed, pretty strongly, heated, and, finally, solidified in dry air. Its density at 24°·45 was then 5·956.—*Comptes Rendus*, lxxxiii, 611, *Phil. Mag.*, ii, 398. E. C. P.

10. *Plasticity of Ice.*—Prof. BIANCONI, of Bologna, in 1871, published some experiments on the bending and torsion of bars and planks of ice (*Mem. Acad. of Bologna*, 3d ser., vol. i.) These show that ice may undergo slow changes of form without any crushing or regelation, and that notwithstanding its brittleness it possesses a slight degree of plasticity. Now Prof. Bianconi gives the results of further experiments on ice, much like those of Heim, or, yet more, those of Mr. Tresca on the puncheoning of metals. Granite pebbles and iron plates are slowly pressed into ice at the same temperatures, and not only do they penetrate into it as they would penetrate into a fluid or semi-fluid, but also the particles of ice are laterally repulsed from beneath the intruding body, and

form around it a rising fringe. Moreover, when a flat piece of iron is pressed into the ice, the fringe rising around it expands laterally upon the borders of the piece, and tends thus, as in fluids, to fill up the cavity made by the body driven in. These experiments tend thus greatly to illustrate the plasticity of ice; but it would be very desirable that Mr. Bianconi if he continues his researches, should accompany them by some measurements (as has already been done by Mr. Heim), in order to obtain numerical values of the plasticity of ice under various circumstances.—*Nature*, xv, 69; *Jour. de Phys.*, v, 317. E. C. P.

11. *Velocity of Electricity.*—Dr. SABINE has devised a method of measuring the contour of electric waves passing through telegraph lines. It is probable that in this sense alone electricity may be said to have a velocity. The early experiments on the time elapsing between starting electricity into one end of a conductor and receiving it at the other end, gave totally contradictory results. This interval would depend on the electromotive force employed, the resistance and capacity of the conductor, and the sensitiveness of the receiving instrument. It would therefore by no means be proportionate to the length. By the following method the electrical condition of any point of the line may be examined quantitatively at intervals of ·001 of a second or less after starting the electric impulse. It thus becomes possible to measure the form and speed of a wave. Suppose one end A of a conductor $A\ B$ is placed to earth, and that the other B is connected with one pole of a battery whose second pole is put to earth. Then any point of the conductor as C will assume a potential which will be proportional to the resistance of $A\ C$. This potential may be measured by connecting C for an instant with a condenser or accumulator, and then discharging the latter through a delicate galvanometer. When the circuit is first closed a minute interval of time is required before C will attain its full potential measurements made of the relation of these quantities show the form of the electric wave passing the point C. The only mechanical difficulty is to construct a chronograph which will allow C to be connected with the condenser, a small but accurately determined time after A is connected with the battery. A heavy wheel of brass is set in motion by a steel spring so that it shall revolve exactly twice a second. The interval through which the spring acts being always the same, a nearly constant velocity is always imparted. The disc is divided into 500 equal parts. A movable index serves to regulate the angle through which the disk turns between the two connections to be recorded. The time of revolution of the disk was first determined by noting the figures read in succession under the film of a small telescope, when the disk was illuminated by half-second flashes of an induction coil. The force of the spring and the position of the trigger releasing it were adjusted until the right velocity was obtained. Recently a condenser was discharged through a known resistance for some interval indicated by the disk, and the time calculated

ording to the leakage formula, from the initial and final read-
s of the galvanometer. If the two do not agree, the spring is
red until they do; but its action is found to be very constant
not to need alteration, except after taking the apparatus to
es for alteration. Several series of experiments are given, and
results show the delicacy and accuracy of the method.—*Phil.*
g., ii, p. 321. E. C. P.

2. *Chemistry and Physics in America. Address before the*
erican Chemical Society at its session on the 16th of last
vember, by Prof. JOHN W. DRAPER, *its President.*—The fol-
ing is the latter half of the able address of Prof. Draper, the
le of which would here be cited if space allowed. “In our
special science, chemistry, all that has been done has only
ed to extend the boundary of what remains. The thousands
nalyses that have been made have brought us into a wilderness
esults. We have not been able to rise to a point of view suf-
ntly high to discover what is the true place of those results in
ure. We try to represent on the pages of our books and on
kboards formulas of the constitution of things, conscious all
time that these are at the best only convenient fictions, which
t necessarily change as we gain a more perfect insight into
grandest of all problems, the distribution of Force in Space,
the variations to which it is liable. The geometry of chemis-
is that of three dimensions, not of two. We have to consider
relation of points not situated on one plane, and hence it is
essary to employ three axes of reference; nay, even more, we
not avoid the conception of the mathematical method of qua-
ions. Our inadequate information respecting the real group-
of atoms is followed as a necessary consequence by imperfec-
in our methods of nomenclature, the confusion in this respect
oming, as we all too well know, every day worse and worse.
nd now while we have accomplished only a most imperfect
mination of objects that we find on the earth, see how, on a
den, through the vista that has been opened by the spectro-
e, what a prospect lies beyond us in the heavens! I often
at the bright yellow ray emitted from the chromosphere of
sun, by that unknown element, Helium, as the astronomers
e ventured to call it. It seems trembling with excitement to
its story, and how many unseen companions it has. And if
be the case with the sun, what shall we say of the magnifi-
t hosts of the stars? May not every one of them have special
nents of its own? Is not each a chemical laboratory in itself?
k at the clusters in the sword-handle of Perseus; in Cassiopeia,
niverse of stars on a ground of star dust; in Hercules, of
ich as astronomers say, no one can look at for the first time
ugh a great telescope without a shout of wonder—the most
erb spectacle that the eye of man can witness! Look at the
ble stars of which so many are now known, emitting their
trasting rays, garnet, or ruby, or emerald, or sapphire. Each
n accordance with its own special physical conditions, though
are under the same universal ordinance.

Now here a fact of surpassing importance presses itself on our attention. The movements taking place in those distant bodies are taking place under the same laws that prevail here on earth, and in our solar system. The law of gravitation, as developed by Newton, bears sway in all those distant worlds. In them bodies attract each other with forces directly as their masses and inversely as the squares of their distances. There the laws of the emission, absorption, and transmission of light are the same as they are with us. There ignited hydrogen gives forth its three rays, the same rays that it gives forth to us. In the uttermost parts of the universe the law of definite combination, the numerical law, and the multiple law, stand good. Sodium absorbs its two waves of definite refrangibility, and iron gives in the spectra its more than a hundred lines, more than a hundred silent but convincing witnesses of the uniformity of the constitution of the universe. There the number of vibrations that constitute a ray of definite refrangibility is the same we have found it to be here. In the enormous heat of those central suns the dissociation of molecules may be of a higher order than we can reach artificially, but the law under which it takes place is a continuation of the law here. There, though the weight of a given mass of matter is different from what it is with us, it is nevertheless determined by the law that determines here—the law of gravitation. There energy is indestructible, and is measured as it is measured among us, by work. Then is there any boundary that we can assign to natural law—is it not omnipresent, universal?

Perhaps there is no exaggeration in the assertion—for there seems abundant proof of its truth—that the light by which we see some of those distant orbs has crossed through such a prodigious space that millions of years have transpired during the journey. Then the phenomena it brings to us are those that were engendered in the beginning of the vast time so passed. Whatever there is that is in harmony with facts now happening here, is to us an unimpeachable evidence that the laws which were governing in those old ages have undergone no depreciation, but are active as ever until now. Then shall I exaggerate if I say that these laws are eternal in duration?

Infinite in influence, eternal in duration, what a magnificent spectacle? In the resistless energy of the motions of the universe is there not omnipotence? The Omnipotent, the Infinite, the Eternal, to what do these attributes belong? Shall a man who stands forth to vindicate the majesty of such laws be blamable in your sight? Rather shall you not with him be overwhelmed with a conception so stupendous? And yet let us not forget that these eternal laws of nature are only the passing thoughts of God.

But grand as this is, there is something still grander. There is another temple into which we have to pass, not that of the visible but that of the invisible. We must persist in the invasion we have made, in the revolution we have brought about in Physiol-

We have to determine the laws which preside in the ner- system of man, and discover the nature of the principle that iates it. Is there not something profoundly impressive in this, the human mind can look from without upon itself, as one s at his phantom image in a mirror, and discern its own linea- ts and admire its own movements. My own thoughts have ite years been forcibly drawn to this, from a recognition that interpretation by the mind of impressions from without takes e under mathematical laws, as for instance, that when exter- ethereal vibrations create in the mind a certain idea, that e idea will arise when the vibrations are doubled, or tripled, uadrupled in frequency; but other ideas will be engendered ibrations of an intermediate rate. Yet what these ideas will ay be predicted. It is true that this is only an optical case, it extends the view that has been offered to us by a study of structure of the ear. In the labyrinthine compartment of that n the ultimate fibers of the auditory nerve are laid on the ling plane of the spiral lamina, in ever-decreasing lengths, capable of trembling to the sound which is in unison with it mechanical action truly, answering to the sympathetic vibra- with which the strings of a piano will respond to the corre- iding notes of a flute—and these are translated by the mind all the utterances of articulate speech, all the harmonies of ic—speech that engenders new ideas within us, strains which, igh they may die away in the air, live forever in the memory. exquisite delight we experience in listening to the works of great composers arises thus in mechanical movements, which he issue of mathematical combinations. The unseen world is r the influence of number!

at what is number except there be one who numbers? When ipey, in his Syrian war, broke into the holy of holies at isalem, he expressed, as Tacitus tells us, his astonishment that e was no image of a Divinity within; the shrine was silent empty. And so, though after death we may anatomize and ore the inmost recesses of the brain, the vailed Genius that presided there has eluded us, and has not left so much as a itom trace, a shadow of himself.

he experiments of Galvani and Volta have not yet reached conclusion; those of Faraday and Du Bois Reymond have yielded a preliminary suggestion as to the nervous force. epting the great sympathetic nerve, the nervous fibers them- es are, as is well-known, of two classes—those that gather the ressions of external things and convey them to the nerve-cen- and those that transmit the dictates of the will from within ardly. The capabilities of one of the former—the apparatus sight—have been greatly improved by various optical con- inces, such as microscopes and telescopes, an earnest of what hereafter be done as respects the four other special organs of e; and as concerns the second class, the result of mental ope- ons, the resolves of the will, may be transmitted with greater velocity than even in the living system itself, and that across vast terrestrial distances, or even beneath the sea. Telegraphic wires are, strictly speaking, continuations of the centrifugal nerves, and we are not without reason for believing that it is the same influence which is active in both cases.

In a scientific point of view, such improvements in the capabilities of the organs for receiving external impressions, such extensions to the distances to which the results of intellectual acts and the dictates of the will may be conveyed, constitute a true development, an evolution, none the less real though it may be of an artificial kind. If we reflect carefully on these things, bearing in mind what is now known of the course of development in the animal series, we shall not fail to remark what a singular interest gathers round these artificial developments—artificial they can scarcely be called, since they themselves have arisen interiorly. They are the result of intellectual acts. Man has been developing himself. He, so far as the earth is concerned, is becoming omnipresent. The electrical nerves of society are spread to a plexus all over Europe and America; their commissural strands run under the Atlantic and the Pacific.

In many of the addresses that have been made during the past summer, on the Centennial occasion, the shortcomings of the United States in extending the boundaries of scientific knowledge, especially in the physical and chemical departments, have been set forth. "We must acknowledge with shame our inferiority to other people," says one. "We have done nothing," says another. Well, if all this be true we ought perhaps to look to the condition of our colleges for an explanation. But we must not forget that many of these humiliating accusations are made by persons who are not of authority in the matter; who, because they are ignorant of what has been done, think that nothing has been done. They mistake what is merely a blank in their own information for a blank in reality. In their alacrity to depreciate the merit of their own country, a most unpatriotic alacrity, they would have us confess that for the last century we have been living on the reputation of Franklin and his thunder-rod.

Perhaps, then, we may without vanity recall some facts that may relieve us in a measure from the weight of this heavy accusation. We have sent out expeditions of exploration both to the Arctic and Antarctic seas. We have submitted our own coast to a hydrographic and geodesic survey, not excelled in exactness and extent by any similar works elsewhere. In the accomplishment of this we have been compelled to solve many physical problems of the greatest delicacy and highest importance, and we have done it successfully. The measuring rods with which the three great base lines of Maine, Long Island, Georgia, were determined, and their beautiful mechanical appliances, have exacted the publicly expressed admiration of some of the greatest European philosophers, and the conduct of that survey their unstinted applause. We have instituted geological surveys of many of our States and much of our Territories, and have been rewarded not merely by manifold local benefits, but also by the higher honor of extending very greatly the boundaries of that noble science. At an enormous annual cost we have maintained a meteorological signal system, which I think is not equaled and certainly is not surpassed in the world. Should it be said that selfish interests have been mixed up with some of these undertakings, we may demand whether there was any selfishness in the survey of the Dead Sea? Was there any selfishness in that mission that a citizen of New York sent to equatorial Africa for the finding and relief of Livingstone, any in the astronomical expedition to South America, any in that to the valley of the Amazon? Was there any in the sending out of parties for the observation of the total eclipses of the sun? It was by American astronomers that the true character of his corona was first determined. Was there any in the seven expeditions that were despatched for observing the transit of Venus? Was it not here that the bi-partition of Biela's comet was first detected, here that the eighth satellite of Saturn was discovered, here that the dusky ring of that planet, which had escaped the penetrating eye of Herschel and all the great European astronomers, was first seen? Was it not by an American telescope that the companion of Sirius, the brightest star in the heavens, was revealed, and the mathematical prediction of the cause of his perturbations verified? Was it not by a Yale College professor that the showers of shooting stars were first scientifically discussed, on the occasion of the grand American display of that meteoric phenomenon in 1833? Did we not join in the investigations respecting terrestrial magnetism instituted by European governments at the suggestion of Humboldt, and contribute our quota to the results obtained? Did not the Congress of the United States vote a money grant to carry into effect the invention of the electric telegraph? Does not the published flora of the United States show that something has been done in botany? Have not very important investigations been made here on the induction of magnetism in iron, the effect of magnetic currents on one another, the translation of quantity into intensity, and the converse? Was it not here that the radiations of incandescence were first investigated, the connection of increasing temperature with increasing refrangibility shown, the distribution of light, heat, and chemical activity in the solar spectrum ascertained, and some of the fundamental facts in spectrum analysis developed long before general attention was given to that subject in Europe? Here the first photograph of the moon was taken, here the first of the diffraction spectrum was produced, here the first portraits of the human face were made—an experiment that has given rise to an important industrial art!

Of our own special science, chemistry, it may truly be affirmed that nowhere are its most advanced ideas, its new conceptions, better understood or more eagerly received. But how useless would it be for me to attempt a description in these few moments of what Prof. Silliman, in the work to which I have already referred, found that he could not include on more than 100 closely printed pages, though he proposed merely to give the names of American chemists and the titles of their works. It would be equally useless and indeed an invidious task to offer a selection; but this may be said, that among the more prominent memoirs there are many not inferior to the foremost that the chemical literature of Europe can present. How unsatisfactory then is this brief statement I have made of what might be justly claimed for American science! Had it been ten times as long, and far more forcibly offered, it would still have fallen short of completeness. I still should have been open to the accusation of not having done justice to the subject.

Have those who gloat over the shortcomings of American science ever examined the Coast Survey Reports, those of the Naval Observatory, the Smithsonian Contributions, those of the American Association for the Advancement of Science, the Proceedings of the American Academy of Arts and Science, those of the American Philosophical Society, the Lyceum of Natural History, and our leading scientific periodicals? Have they ever looked at the numerous reports published by the authority of Congress on geographical, geological, engineering, and other subjects—reports often in imposing quartos magnificently illustrated.

Not without interest may we explore the origin of the depreciation of which we complain. In other countries it is commonly the case that each claims for itself all that it can, and often more than is its due. Each labors to bring its conspicuous men and its public acts into the most favorable point of view; each goes upon the maxim that a man is usually valued at the value he puts upon himself. But how is it with us? Can an impartial person read without pain the characters which we so often attribute to our most illustrious citizens in political, and what is worse, in social life? Can we complain if strangers accept us at our own depreciation, whether of men or things?

We need not go far to detect the origin of all this—it is in our political condition. Here wealth, power, preferment—preferment even to the highest position in the nation—are seemingly within the reach of all, and in the internecine struggle that takes place every man is occupied in pushing some other man into the background. I fear that in political life there is no remedy for this, such is the violence of the competition, so great are the prizes at stake. But in the less turbulent domain of science and letters we may hope for better things. And those who make it their practice to decry the contributions of their own country to the stock of knowledge may perhaps stand rebuked by the expressions that sometimes fall from her generous rivals. How can they read without blushing at their own conduct such declarations as that recently uttered by the great organ of English opinion, the foremost of English journals? The Times, which no one will accuse of partiality in this instance, says: "In the ral distribution of subjects, the history of enterprise, discovery, conquest, and the growth of republics fell to America, and has dealt nobly with them. In the wider and multifarious rinces of art and science she runs neck and neck with the her country and is never left behind!"

here are among us some persons who depreciate science merely ugh illiterate arrogance; there are some who, incited by rficiality, dislike it; there are some who regard it with vil eye, because they think it is undermining the placid tranlity they find in lifelong cherished opinions. There are some hate it because they fear it, and many because they find that in conflict with their interests. But let us who are the servants cience, who have dedicated ourselves to her, take courage. by day the number of those who hold her in disfavor is inishing. We can disregard their misrepresentations and dictions. Mankind has made the great discovery that she is long hoped-for civilizing agent of the world. Let us continue labor unobtrusively, conscious of the integrity of our motives, cious of the portentous change which is taking place in the ght of the world, conscious of the irresistible power which is nd us! Let us not return railing for railing, but above all, us deliver unflinchingly to others the truths that Nature has vered to us!

he book of Nature! shall not we chemists, and all our brotherents, whether they be naturalists, astronomers, mathematicians, ogists, shall we not all humbly and earnestly read it? Nature, mother of us all, has inscribed her unfading, her eternal record he canopy of the skies, she has put it all around us on the form of the earth! No man can tamper with it, no man can polate or falsify it for his own ends. She does not command hat to do, nor order us what to think. She only invites us to around. For those who reject her she has in reserve no nges, no social ostracism, no *index expurgatorius*, or *auto da* To those who in purity of spirit worship in her heavenlioned temple, she offers her guidance to that cloudy shrine which Truth sits enthroned, "dark with the excess of light!" her are repairing, not driven by tyranny, but of their own rd, increasing crowds from all countries of the earth, conscious whatever their dissentions of opinion may heretofore have , in her presence they will find intellectual concord and unity.

Prof. Draper's researches in Physics.—Prof. Draper's reches are a very prominent part of the scientific work of the try. We cite the following from the Address of the Presi- of the American Academy of Arts and Sciences, in March on the presentation to Prof. Draper of the Rumford medals. DS.

an elaborate investigation, published in 1847, Dr. Draper established experilly the following important facts: 1. All solid substances, and probably ls, become incandescent at the same temperature. 2. The thermometric at which substances become red-hot is about 977° Fahr. 3. The spectrum incandescent solid is continuous; it contains neither bright nor dark fixed lines. 4. From common temperatures nearly up to 977° Fahr., the rays emitted by a solid are invisible. At that temperature they are red, and the heat of the incandescing body being made continuously to increase, other rays are added, increasing in refrangibility as the temperature rises. 5. While the addition of rays, so much the more refrangible as the temperature is higher, is taking place, there is an increase in the intensity of those already existing. Thirteen years afterward Kirchhoff published his celebrated memoir on the relations between the coefficients of emission and absorption of bodies for light and heat, in which he established mathematically the same facts, and announced them as new. 6. Dr. Draper claims, and we believe with justice, to have been the first to apply the daguerreotype process to taking portraits. 7. Dr. Draper applied ruled glasses and specula to produce spectra for the study of the chemical action of light. The employment of ruled metallic specula for this purpose enabled him to avoid the absorbent action of glass and other transparent media, as well as to establish the points of maximum and minimum intensity with reference to portions of the spectrum defined by their wave lengths. He obtained also the advantage of employing a normal spectrum in place of one which is abnormally condensed at one end and expanded at the other. 8. We owe to him valuable and original researches on the nature of the rays absorbed in the growth of plants in sunlight. These researches prove that the maximum action is produced by the yellow rays, and they have been fully confirmed by more recent investigations. 9. We owe to him, further, an elaborate discussion of the chemical action of light, supported in a great measure by his own experiments, and proving conclusively, and, as we believe, for the first time, that rays of all wave-lengths are capable of producing chemical changes, and that too little account has hitherto been taken of the nature of the substance in which the decomposition is produced. 10. Finally, Dr. Draper has recently published researches on the distribution of heat in the spectrum, which are of the highest interest, and which have largely contributed to the advancement of our knowledge of the subject of radiant energy.

II. GEOLOGY AND MINERALOGY.

1. *Explorations made under the direction of F. V. Hayden, in* 1876.—For reasons beyond the control of the Geologist in charge, the various parties composing the United States Geological and Geographical Survey of the Territories, did not commence their field work until August. Owing to the evidence of hostility among the northern tribes of Indians it was deemed most prudent to confine the labors of the survey to the completion of the Atlas of Colorado. Therefore the work of the season of 1876 was a continuation of the labors of the three preceding years, westward, finishing the entire mountainous portion of Colorado with a belt fifteen miles in width of northern New Mexico and a belt twenty-five miles in breadth of eastern Utah. Six sheets of the Physical Atlas are now nearly ready to be issued from the press. Each sheet embraces an area of over 11,500 square miles, or a total of 70,000 square miles. The maps are constructed on a scale of four miles to one inch with contours of 200 feet, which will form the basis on which will be represented the geology, etc. The areas of exploration the last season are located in the interior of the continent, far remote from settlements and among the hostile bands of Ute Indians that attacked two of the parties the previous year.

Five parties were engaged in field duty: one for completing the primary triangulation of Colorado, three for topographical and geological work, and one for making observations in natural history.

The primary triangulation party was placed in charge of A. D. Wilson and took the field from Trinidad, the southern terminus of the Denver and Rio Grande Railway, August 18th, making the first station on Fisher's Peak. From this point the party marched by the valley of the Purgatoire, crossed the Sangre de Christo range by way of Costillia Pass, followed the west base of the range northward as far as Fort Garland, making a station on Culebra Peak. About six miles north of Fort Garland is located one of the highest and most rugged mountain peaks in the west, called Blanca Peak, the principal summit of the Sierra Blanca group. This was ascended by the party under Mr. Wilson, and found to be the highest peak in Colorado and the second peak in height in the United States. A comparison with some of the first class peaks in Colorado will show the relative heights.

Blanca Peak	above sea	level,	14,464 feet.
Mt. Harvard	"	"	14,384 "
Gray's Peak	"	"	14,341 "
Mt. Lincoln	"	"	14,296 "
Mt. Wilson	"	"	14,280 "
Long's Peak	"	"	14,271 "
Uncompahgre Peak	"	"	14,235 "
Pike's Peak	"	"	14,146 "

Mr. Wilson made eleven primary stations over a large portion of Southern and Western Colorado and completed about 1,000 square miles of topography that had been omitted by one of the parties of last year.

In company with the triangulation party, Mr. Holmes made a hurried trip through Colorado, touching also portions of New Mexico and Utah. He was unable to pay much attention to detailed work, but had an excellent opportunity of taking a general view of the two great plain belts that lie, the one along the east, the other along the west base of the Rocky Mountains. For nearly 2,000 miles travel he had constantly in view the Cretaceous and Tertiary formations, among which are involved some of the most interesting geological questions. He observed among other things the great persistency of the various groups of rocks throughout the east, west and north, and especially in the west; that from Northern New Mexico to Southern Wyoming the various members of the Cretaceous lie in almost unbroken belts, while the Tertiaries are hardly less easily followed.

Between the east and the west there is only one great incongruity. Along the east base of the mountains the upper Cretaceous rocks, including Nos. 4 and 5, are almost wanting and consisting at most of a few hundred feet of shales and laminated sandstones. Along the west base this group becomes a prominent and important topographical as well as geological feature. In the southwest, where it forms the "Mesa Verde" and the cap of the Dolores plateau, it comprises upward of 2,000 feet of coal-bearing strata, chiefly sandstones, while in the north it reaches a thickness of 3,500 feet and forms the gigantic hog-back of the Grand River valley.

While in the southwest, he visited the Sierra Abajo, a small group of mountains which lie in Eastern Utah, and found as he had previously surmised that the structure was identical with that of the four other isolated groups that lie in the same region. A mass of trachyte has been forced up through fissures in the sedimentary rocks and now rests chiefly upon the sandstones and shales of the lower Cretaceous. There is a considerable amount of arching of the sedimentary rocks, caused probably by the intrusion of wedge-like sheets of trachyte, while the broken edges of the beds are frequently bent abruptly up as if by the upward or lateral pressure of the rising mass. He was able to make many additional observations on the geology of the San Juan region, and secured much valuable material for the coloring of the final map.

He states that the northern limit of ancient cliff builders in Colorado and Eastern Utah is hardly above latitude 37° 45′.

The Grand River Division was directed by Henry Gannett, topographer, with Dr. A. C. Peale as geologist. James Stevenson, executive officer of the survey, accompanied this division for the purpose of assisting in the management of the Indians, who last year prevented the completion of the work in this locality by their hostility.

The work assigned this division consisted in part of a small area containing about 1,000 square miles lying south of the Sierra la Sal. The greater portion of the work of this division lay north of the Grand River, limited on the north by the parallel of 39° 30′ and included between the meridians of 108° 00′ and 109° 30′.

The geological work of this division, by Dr. Peale, connects directly with that done by him in 1874 and 1875. Sedimentary formations prevail in both districts visited during the past season.

The country first examined lies between the San Miguel and Dolores Rivers, extending northward and northwestward from Lone Cone Mountain. The general character of this region is that of a plateau cut by deep gorges or cañons, some of which, especially toward the north, extend from the sandstones of the Dakota group to the top of the Red Beds. The depth of the cañon however is no indication of its importance as a stream bed, for away from the main streams they are dry the greater portion of the year. There are no great disturbances of the strata, what folds do occur being broad and comparatively gentle.

The San Miguel River leaving the San Juan Mountains flows toward the northwest and, with its tributaries, cuts through the sandstones of the Dakota group, exposing the variegated beds lying beneath that have generally been referred to the Jurassic. About twenty-five or thirty miles north of Lone Cone, the river turns abruptly to the west and flows west and southwest for about fifteen miles, when it again turns and flows generally northwest until it joins the Dolores. Between the San Miguel and e Cone the sandstones of the Dakota group or No. 1 Creta- is are nearly horizontal, forming a plateau which on approach- the mountains has a capping of Cretaceous shales.

eyond the bend, the San Miguel flows in a monoclinal valley which the cañon walls are of the same description as in the er part of its course. As the mouth is approached the Red s appear. Between this portion of the course of the San Miguel the almost paralled course of the Dolores, which is in a simi- monoclinal rift, there are two anticlinal and two synclinal eys parallel to each other. They are all occupied by branches he Dolores. Lower Cretaceous, Jurassic and Triassic strata rop and present some interesting geological details which will ully considered in the report on the district. The Dolores r comes from a high plateau in a zigzag course, flowing some- s with the strike and sometimes with the dip of the strata. general course on the western line is about northwest from h it turns to the northward and westward, finally changing orthwest again to its junction with the Grand. It is in a n the greater part of its course.

the region of country north of Grand River, the geological ations extend uninterruptedly from the Red Beds exposed on d River to the White Tertiary cliffs forming the summit of e "Roan Mountains" or Book Cliffs. The Grand is generally cañon in the Red Beds. On the north side the No. 1 Cre- ous sandstones form a hogback sloping toward the cliffs. veen the crest of this hogback and the cliffs, there is a broad y formed by the erosion of the soft Cretaceous shales which nd to the base of the cliffs and in some places form their r portion.

ie cliffs are composed mainly of Cretaceous beds, rising one e another in steps, until an elevation of about 8,000 feet is hed. The summit is the edge of a plateau, sloping to N.N.E. plateau is cut by the drainage flowing into the White River the south. These streams rarely cut through the Tertiary s.

oal of poor quality is found in the sandstones of the Dakota p and also in the sandstones above the middle Cretaceous . Wherever noticed it was in thin seams and of little omic importance.

ie White River division was directed by G. B. Chittenden as grapher, accompained by F. M. Endlich as geologist.

ie district assigned to this party as their field for exploration ng the season of 1876, commenced from the eastward at itude 107° 30′, joining on to the work previously done and nded westward 30 miles into Utah Territory. Its southern idary was N. latitude 39° 30′, while the White River formed iorthern limit. In order to complete the work to the greatest ible advantage in the shortest time that could be allowed, it determined to make the White River Agency headquarters, in two trips from there complete the work. About 3,800 re miles comprised the area surveyed.

According to the report of F. M. Endlich, the geology of the district is very simple though interesting. Inasmuch as but one divide of importance occurred within the district, the work was somewhat simplified. This was formed by the "Book Cliffs," between the drainage of the Grand on the south and the White on the north. Both of these rivers flow a little south of west, into the Green River which they join in Utah. From the junction of the Grand and Green downward the river is called the Great Colorado. Orographically, the region surveyed is comparatively simple. The "Book Cliffs" are the summit of a plateau about 8,000 feet above sea level, continuing unbroken over to the Green River. Toward the south these cliffs fall off very steeply, forming deep cañons that contain tributaries of the Grand River. On the north side—with the dip of the strata—the slope is more gentle, although in consequence of erosion numerous precipitous cliffs are formed. Descending in that direction the character of the country changes. Instead of an unbroken slope, we find that the plateau has been cut parallel by the White River drainage, and the long, characteristic mesas of that region testify to the action of erosion. Approaching the river, constantly descending with the slight dip of the strata, the bluffs become lower and lower. Though the creek valleys are wide and at certain seasons no doubt well watered, the vegetation is that of an arid country. Dwarf pines, piñons and sage brush abound, to the almost entire exclusion of other trees or grass. Traveling down White River this character is again found to change. A new series of bluffs, occasioned by heavy superincumbent strata, gives rise to the formation of deep cañons. For 45 miles the party followed the cañon of White River, that, no doubt, is analogous to that of Green River, and probably closely resembles that of the Colorado in its detail features. Vertical walls enclose the narrow river-bottoms, and the slopes of the higher portions are ornamented by thousands of curiously eroded rocks. Monuments of all kinds and figures that can readily be compared to those of animated beings enliven the scenery, which would otherwise be monotonous Two to three thousand feet may be stated as the height of the walls enclosing the White River.

Geologically speaking, the district was one of singular uniformity. Traveling westward, the older formations, reaching back as far as the Jurassic, were found. These were followed by Cretaceous which in turn was covered with Tertiary. About three-quarters of the region surveyed was found to contain beds belonging to this period. Owing to the lithographical character of the strata, water was a rare luxury in this region, and men and animals were frequently dependent upon springs. Farther west still, the Green River group sets in, forming those numerous cañons of which that of the White River is one.

The field work of the Yampah division, under Mr. G. R. Bechler as topographer and Dr. C. A. White as geologist, during the past season was principally confined to a district of north-

ern Colorado lying between the Yampah and White Rivers,
between Green River and the subordinate range of mountains
lies west of and parallel with the Park Range. The area is
:aced between parallels 39° 30′ and 40° 30′, and meridians 107°
nd 109° 30′.

ie rocks of this district embrace all the sedimentary forma-
ı yet recognized by the investigators who have studied the
ın that lies between the Park Range and the Great Salt
;, namely from the Uinta Quartzite (which underlies the
›oniferous) to the latest Tertiary, inclusive. Not only has
geographical distribution of these formations been mapped,
all the displacements of the strata have been traced and
ıeated. The last named investigations bring out some
esting and important facts, in relation to the orographic
›gy of the region, especially as regards the eastern termination
ie great Uinta uplift and the blending of its vanishing pri-
r and accessory displacements with those of the north and
ı range above mentioned. Much information was also
ined concerning the distribution of the local drift of that
ın; the extent and geological date of outflows of trap, etc.

ie brackish water beds at the base of the Tertiary series,
ıining the characteristic fossils, were discovered in the valley
ie Yampah. They are thus shown to be exactly equivalent
those now so well known, in the valley of Bitter Creek,
›ming Territory. These last named localities were also
ed at the close of the season's work, and from the strata of
horizon at Black Buttes station, three new species of *Unio*
obtained, making six clearly distinct species in all that have
obtained associated together in one stratum at that locality.
r are all of either distinctively American types or closely
ed to species now living in American fresh waters. They
sent, by their affinities, the following living species; *Unio*
ıs Lamarck; *U. securis* Lea; *U. gibbosus* Barnes; *U. meta-*
us Rafinesque, and *U. complanatus* Solander. They are asso-
d in the same stratum with species of the genera *Corbula*,
icula, *Neritina*, *Viviparus*, etc., and which stratum alternates
layers containing *Ostrea* and *Anomia*.

ie close affinity of these fossil *Unios* with species now living
e Mississippi River and its tributaries, seems plainly sugges-
of the fact that they represent the ancestry of the living ones.
nteresting series of facts has also been collected, showing that
of the so-called American types of *Unio* were introduced in
; is now the great Rocky Mountain region, as early as the
ssic period, and that their differentiation had become great
clearly defined as early as late Cretaceous and early Tertiary
s. Other observations suggest the probable lines of geographi-
distribution, during the late geological periods, of their
ıtional descent, by one or more of which they have probably
ıed the Mississippi River system and culminated in the
erous and diverse forms that now exist there.

The work of the past season shows very clearly the harmonious relation of the various groups of strata over vast areas, that although there may be a thickening or a thinning out of beds at different points, they can all be correlated from the Missouri River to the Sierra Nevada Basin. The fact also that there is no physical or paleontological break in these groups over large areas, from the Cretaceous to the middle Tertiary is fully established. The transition from marine to brackish water forms of life, commences at the close of the Cretaceous epoch and, without any line of separation that can yet be detected, continues on upward until only purely fresh water forms are to be found. Dr. White, an eminent paleontologist and geologist says that the line must be drawn somewhere between the Cretaceous and Tertiary epochs, but that it will be strictly arbitrary, as there is no physical break to the summit of the Bridger group. H.

2. *Geological Survey of Kentucky.*—Chemical examination of the Ashes of the Hemp and Buckwheat Plants, with remarks on its bearing on Hemp Culture in Kentucky, by R. Peter, M.D., Chemist to the Survey. Publications of the Geological Survey of Kentucky under N. S. Shaler, Director. Part III, vol. ii. Second Series. 25 pp. 8vo. Frankfort, Kentucky.—The following remarks on hemp and the analyses are copied from pages 11 to 13 of this Report. "In order to ascertain the relative fertilizing influence of the leaves and roots, three hemp plants were collected, July 25th, 1864, in *the dry season.* These, one male and two female plants, were about six to seven feet high. The leaves, stems and roots, carefully separated and thoroughly air dried, weighed as follows:

The leaves weighed 23·916 grams, equal to about 30· per cent of the whole plant.
The roots " 7·433 " " 9·3 " " "
The stems " 48·430 " " 60·7 " " "

These were separately incinerated and their ashes analyzed, with the following results:

RELATIVE ASH INGREDIENTS OF THE LEAVES, ROOTS, AND STEMS OF THE HEMP, CARBONIC ACID EXCLUDED.

	THE LEAVES.		THE STEMS.		THE ROOTS.	
	In 100 p'ts of ash.	In 100 p'ts of dried leaves.	In 100 p'ts of ash.	In 100 p'ts of dried stems.	In 100 p'ts of ash.	In 100 p'ts of dried roots.
Lime	48·819	4·992	23·371	0·949	20·368	0·713
Magnesia	5·726	·585	5·803	·194	8·297	·291
Potash	27·955	2·858	49·599	1·659	52·233	1·829
Soda	·236	·024				
Phosphoric acid	9·264	·947	13·374	·447	15·164	·531
Sulphuric acid	2·209	·226	1·215	·040	1·344	·047
Chlorine	·171	·017	·576	·019	·405	·014
Silica	5·620	·575	1·062	·035	2·189	·077
Per cent of phosphates	19·160	1·959	28·158	0·942	26·885	0·949
Per cent of ash	....	10·225	....	3·346	....	3·502

camination of the above table it is to be seen, that the f the flowering hemp contain more of the essential min-redients of the soil than all the other parts of the plant; ting as they do, about 30 per cent of the whole plant in ried state, and yielding 10·225 per cent of their weight of carbonic acid being excluded; while the stems and roots, gether form the remaining 70 per cent of the weight of t, give an average of less than 3·5 per cent of ash.

this great excess in the proportion of ash in the leaves due to the influence of the greater evaporation which takes their surfaces, causing a deposit or incrustation of lime nesia salts and silica of the nature of stalagmite; for we while the amount of *silica* in the leaves is nearly fourteen eater than that in the stems, and more than seven times than in the roots; the *lime* more than five times as great n the stems, and seven times more than in the roots; the *a* three times more than that in the stems, and twice as that in the roots; the *phosphoric acid* and *phosphates alkalies* are in nearly double proportion in the leaves also, sulphuric acid five times greater in them than in the nd about four times greater than in the roots. So that e leaves, when in their fully matured state or when they r fall, may possibly contain scarcely any but the less alts which may be left in their tissues on the evaporation rbonated water which held them in solution in the sap, tain, when in the growing, active condition, like all other rbage, a very large proportion of salts of potash, and of ineral elements of plant nourishment, and hence may enrich the soil on which they decay. It is obviously to rest of the hemp farmer, therefore, so to manage as to em as regularly as possible over his hemp ground.

American Bison, Living and Extinct; by J. A. ALLEN. d, by permission of N. S. Shaler, Director of the y Geological Survey, as vol. iv, No. 10, of the Memoirs Museum of Comparative Zoology at Harvard College. ge, Mass. 246 pp. 4to, with 12 plates and a colored map. Bigelow & Co.).—This work, beautiful in typography, as n its illustrations, is a carefully prepared monograph of rican bisons, containing, as its first part, descriptions of ies, and, as its second, a thorough discussion of their ical distribution. Two extinct species are recognized, *tifrons* Leidy, and *B. antiquus* Leidy (= *B. crassicornis* on). To the description of *Bison Americanus* the author d much information on the habits of the species from his rvations. The fine colored map is introduced to illustrate r and present distribution.

ond Geological Survey of Pennsylvania. Harris-

eport of Progress in the Greene and Washington District ituminous Coal-fields of Western Pennsylvania, by J. J.

STEVENSON. 420 pp. 8vo, with 3 sections and 2 County maps, showing the calculated local depths of the Pittsburg and W.

(2.) Report of Progress in the District of York and Adams Counties. 196 pp. 8vo, with Maps and Cross-sections showing the Iron-ore belts and individual Mines; by PERSIFOR FRAZER, Jr.

Mr. Stevenson's Report, after chapters on the physical features of the district and its Quaternary geology, describes in detail the Carboniferous strata, their nature, positions and relations, and then takes up the special geology of the several townships, giving numerous sections, and much information on the coal beds and coals. The closing chapter, on Economic Geology, contains information as to the thickness and variations of the coal beds, the composition of coals, constitution and value of the iron-ores, and on the distribution and source of the petroleum of the district. Mr. Stevenson concludes, with regard to the oil, that it has not arisen from the distillation of shales, but that "it is in the highest degree probable that the vegetable matter [that of the oil-bearing sandstone beds] instead of being converted into coal was converted into petroleum, and that the oil is indigenous to these sandstones."

The Terraces of the Ohio and Alleghany valleys are described as generally well defined. The upper is of various heights, 180, 250, and even 480 feet. From Monongahela to Pittsburg terraces are stated to be very distinct at 190 and 290 feet; while at the former place there are seven terraces at 40, 120, 190, 290, 340, 400, and 480 feet; and below Pittsburg, at Chartiers, there are six, the highest 390 feet. They indicate great height in those valleys for the Glacial flood, when water and earthy material were both, for a long period, of indefinite supply from the melting of the glacier.

Mr. Frazer treats of a belt in Eastern Pennsylvania which includes numerous limonite beds associated with granular limestone and hydromica slates, similar in character and position to those characterizing the Green Mountain region in Berkshire, Mass., and Salisbury, Connecticut, and the adjoining parts of New York, and also in Vermont. The relative position of the rocks is made a special study, and several sections presenting the author's present views on this subject are given, though with some expressions of uncertainty. The main point set forth is that the limestones and slates are not conformable—which is at variance with most (not all) of the sections observed by the writer in Berkshire. The volume also contains descriptions of some trap rocks, analyses of hydromica slates, limestones, and detailed descriptions and analyses of iron ores.

5. *On the Glacial Phenomena of North America;* by Professor OTTO TORELL, of Sweden. (Proc. Amer. Assoc., Buffalo.)—The following is a report of the paper by Professor Torell in the New York Times of August 30.—It may be assumed that the circumstances essential to the formation and movement of glaciers are these: 1. Abundance of moisture in the atmosphere; 2. A low temperature, due either to great elevations in low latitudes, or to

high latitudes with or without such elevations of land. These conditions insure such accumulations of snow above the line of perpetual frost as will sooner or later pass the line of perpetual snow and be changed to ice and water. The water becomes glacial rivers, and the ice will move as a plastic mass to a line determined by the amount of snow, on the one hand, and the climate on the other. The advancing movement of the glacier is accompanied by erosion and scratching of the rocks below and by the different kinds of moraines, as till or blue bowlder clay, and yellow unstratified masses—terminal, lateral, and superficial moraines. Simultaneous with these phenomena we have this action of the glacial river, namely, a partial denudation of the moraines, and the formation of stratified gravel, sand, and clay.

The glacial phenomena of the Glacial period were as follows: 1. The sinking of the temperature, accompanied by the formation and increase of glaciers; 2. The motion of the ice to its extreme limit; 3. The formation of moraines, of which a part were moved forward and constituted terminal moraines, while another portion was passed over by the ice, and then became bottom or ground moraines; 4. The removal by this advancing glacier of the glacial river deposits, or the covering of them by the glacier itself and its ground moraine. A geological section of the edge of the ice would then present either (*a*) preglacial beds; (*b*) stratified glacial deposits; (*c*) a ground moraine; (*d*) the ice with its terminal moraine: or (*a*) scratched rocks; (*c*) a ground moraine; (*d*) ice and terminal moraines. The first-named section is most common in the portions of Europe covered by Scandinavian erratics. The second is found generally in Scandinavia and in the United States.

The retrograde movement of a glacier during the period of melting is characterized: 1. By the formations of upper or terminal moraines, which are more or less leveled by local backward and forward movements of a glacier during successive intervals of time; 2. By stratified river deposits lying upon the unstratified yellow moraine, so that a section above the sections just described will present (*a*) preglacial beds; (*b*) stratified deposits; (*c*) till or ground moraine; (*d*) terminal moraines leveled down to great fields containing unstratified materials; (*e*) stratified beds formed by glacial rivers with gradually descending sources. The characteristics of deposits (*b*) are that only in the vicinity of high mountains they contain rounded stones, while farther away they consist of deposits of sand and clay. The characteristics of the deposits (*c*) are: A blue color, due to the seclusion from the oxidizing action of the air; compactness and hardness; rounded form of the bowlders, which are polished and scratched, and also generally brought from remote places. The characteristics of the deposits (*d*) are: A yellow and reddish color, occasioned by peroxidation of iron, comparative looseness of the mass, and greater angularity of the bowlders, which are rarely scratched, and usually belong to neighboring localities. The characteristics of the deposits (*e*) are: Stratification, abundance of rounded and unscratched bowlders; they generally consist of beds of gravel and sand, without clay. These phenomena are found not only in Europe wherever there are traces of the ice age, but are observable in the United States and in the region to the north of them. Each glacier has had its own limited area, and the same appears to have been the case with all the great drift deposits in North America. The greatest ice-field of Europe was that which originated in the highlands of Scandinavia, and thence extended over those portions of Northern Europe which are known to be covered by Scandinavian erratics.

By investigations extending through a long period of years, I have found that the above-mentioned glacial beds or deposits exist in all the countries above indicated. The Scandinavian glacier crossed the Baltic and German Ocean, and extended its moraines into the suburbs of London on the west, to the slopes of the Riesengebirge in the southeast, to the Tjernaye Bay, the icy, on the northeast. The presence of precisely similar phenomena in North America has established in the minds of a majority of geologists the conviction that a vast area over which such phenomena are found has also been covered with ice. But if we carefully examine this region it will readily appear that the glacial area is not continuous from ocean to ocean, but it is divisible into a northwestern area, and the Rocky Mountain area and others to the west, separated by a broad, driftless belt extending from the base of the Rocky Mountains nearly to the Mississippi, thus forcing the conclusion that the great Eastern and Western ice-fields have had different sources.

It has been the opinion of many distinguished American geologists that the source of the eastern ice-fields is to be sought in the Canadian highlands. Against this opinion several important reasons may be urged. First, in the portions of Canada in which the glaciers in question are supposed to have originated, we have reason to believe that the rocks are rounded and scratched, phenomena everywhere recognized as glacial; but I think in no case characterizing rocks known to have been covered with perpetual snow. Again, the elevation and extent of the highest portions of Canada are hardly sufficient to account for the requisite accumulation of snow and ice. And finally, so far as I have learned, there is not formed upon the rocks of the northern slope of Canada, nor yet in bowlders moved by glacial force, any satisfactory evidence that there had been a northward as well as southward movement of glaciers from the highlands of Canada. If, therefore, the phenomenon of the northern and eastern United States, usually supposed to be glacial, are indeed such, and if there is not sufficient reason for assuming the Canadian highlands to have been the source of the glaciers which produced these phenomena, then the source of them must be sought for elsewhere.

I think it will be conceded by all geologists who have studied the glacial phenomena of these regions that both the character of the erratics and the direction of the scratches upon the rocks show that this source must lie to the northeast. Following the line of the glacial movement across Baffin's Bay and Davis' Strait to Greenland, we find that the largest body of land in the northern hemisphere, covered by ice and snow to a depth of not less than 2,000 feet, and at this moment sending down its icebergs as far as the Middle Atlantic. From the sixtieth degree of latitude to above the eightieth, this vast area of land is known to be ice-covered, and from the scarcity of the icebergs upon the eastern compared with the western coast of that land, it may be concluded that the general slope of the surface is to the southwest, and in exact direction of the glacial markings of what is known to have been the course of transported bowlders in Northeastern America. Moreover, if we bear in mind the certainty that during the Glacial period the glaciers moving from the heights of Greenland toward the sea could not have formed detached icebergs as now, but must have for the time blocked up all avenues except the one of easiest escape for the immense accumulations of ice, we may easily assume that this avenue was southwestward across British America and the northeastern part of the United States.

Finally, it may be remarked that this view is strongly confirmed by comparison of the Scandinavian with the American glacial area, for in addition to the identity of the general phenomena there is observable a marked resemblance in the proportion between the extent and other circumstances of the two areas, and that by allowing due weight to all the evidences adduced in support of the view that Greenland was the source of the glacial phenomena of the area in question, we find a probable and rational solution of a hitherto unsettled problem.

6. *Note on the Glacial era;* by JAMES D. DANA.—Professor Torell, in his important paper on the Glacial phenomena of North America, supposes that we differ in our views. It is a pleasure to know that we agree in all essential points. No American geologist holds, so far as I know, that "the source of the eastern ice-fields of North America is to be sought in the Canadian highlands." In my papers on this subject in this Journal for 1871 (ii, 24) and 1873 (v, 204), I was speaking of the "Glacier of New England," that is, the New England part of the great glacier; and, the conclusion arrived at was that the glacial scratches over New England, New York, and the region of Canada just north, *converge* toward an area on the Canadian watershed; and hence that the movement over New England and New York diverged from this area. I say that "the scratches of Eastern Canada, of the high land of Northern New England, of Eastern and Western New York, and of Northwestern Canada, point to a part of the Canada water-shed between the St. Lawrence Valley and Hudson Bay as the head of the glacier that moved southeastwardly over New England." I regret that my words were in any

way calculated to mislead. Professor Torell corrects the above view by making Greenland the great source; but to put Greenland in the above sentence would make it absurd, for no height of ice in that land, so far to the northeast, could have determined *southeastward movements over New England.* I did not doubt that the ice mass of the Canada water-shed, continued northward or northeastward, in the direction of the region of greatest precipitation, as the chief ice-mass of the continent; but only whether the increase of height in that direction exceeded enough that on the water-shed to cause movements in the directions indicated. I concluded that the height of the ice-surface on the water-shed would have had to have been at least 13,000 feet to have given it a slope of even fifteen feet a mile to its discharge in the ocean south and east of New England and ten feet a mile to the ice-surface over Mount Washington—the smallest pitch that seemed to be capable of producing the southward and southeastward movement; and the adding of ten feet a mile to the height farther north, thus increasing this already incredible altitude I allude to (ii, 328) but with an improbable *if.* The region of greatest height to the north of the water-shed I did not consider, because it was not within the range of my subject—the source of the "New England Glacier;" and I had no satisfactory facts as to the present amount of precipitation to the north, much less any data for judging of the hygrometric condition in the Glacial era.

In this Journal for April, 1875 (ix, 312), in citing facts from Dr. Bell, in the Report of the Canada Geological Survey for 1873-4, I observe that the facts from the vicinity of Lake Winnipeg show that a line of greatest glacier height was continued from the ice-summit on the Canada water-shed northward; but not necessarily that the height northward "was as great as over the water-shed," for "the greatest height would have been where there was the greatest amount of precipitation, supposing the melting the same." I then explain the absence of the glacier from the central regions of the continent (exclusive of the Rocky Mountains) by reference to the small amount of precipitation (referring to Schott's Rain-chart), and to the high degree of summer heat, thus making the glacier, as I state, a great coastward ice-mass, thinning out to the westward; and the Continental ice, not an ice-cap, but, as I say in a subsequent note (x, 385, 1875), an "ice-mantle thrown about the pole and descending along the borders of the Continent, especially the eastern."

6. *A monograph of American Trilobites;* by A. W. VOGDES, U. S. Army. 16 pp. Tampa, Florida.—This pamphlet is Part I of Lieut. Vogdes' monograph. It is wholly bibliographical, giving the general bibliography on the subject, from the first paper, in 1698, by Lhwyd, and then, references to the works or memoirs that treat of the several species of the genera ***Asaphus***, ***Odontopleura*** (Acidaspis), ***Proëtus***, ***Bathyurus***, ***Bathyurellus***, ***Agraulos***, ***Ptychoparia*** (Conocephalites), and ***Ceraurus***.

ıutline of the Geology of Canada, based on a subdivision
›vinces into natural areas; by E. J. CHAPMAN, Prof. Min.
, University College, Toronto, Canada. 106 pp. 8vo,
ral maps and plates of fossils.—Prof. Chapman's work is
sumé of the facts in Canadian geology, preceded by an
ion, of 32 pages, on rock-formations and divisions of geo-
me. The work is a convenient one for the student and
ıe geologist who would acquire a general knowledge of
merican Geology. It contains six plates of fossils repre-
anadian species.

rin of Forest and Prairie regions.—Prof. J. D. Whitney
ıable paper on this subject in the American Naturalist
er and November.

; Great Ice Age and its relations to the Antiquity of
JAMES GEIKIE, F.R.S., of H. M. Geological Survey of
2d edit. revised. 624 pp. 8vo, with several maps and
illustrations. London, 1877. (Daldy, Isbister & Co.).
second edition, Prof. Geikie's very popular work has
various additions from recent observations, partly per-
.de in Britain, and from researches in other countries,
included; and, as the author's preface states, much of it
rewritten. The subject is well treated in all its different
and the illustrations are excellent. The maps include one
America, showing the southern outline of the glacier and
·al courses of erosion. Among the changes of views
d, are the use now of the terms till and bowlder clay
ly synonymous;" and the adoption of the conclusion of
əson, that "the sea had not any share in the formation of
ı." The work is the best review of the subject to be had,
much of its value to Professor Geikie's own researches.

III. BOTANY AND ZOOLOGY.

: of Publication of Elliott's Botany of South Carolina
gia.—The title-page of the first volume bears the date
But it is well known that the work was issued in parts,
:he publication began much earlier. The actual time of
›mes important in respect to the priority of certain ge-
specific names, notably those in Nuttall's *Genera*, pub-
1818. Contrary to the testimony of the title-pages, it is
understood that Elliott's names of *Podostigma* and
have priority over Nuttall's *Stylandra* and *Anantherix.*
future trouble it is desirable to put upon record such
ıpon the point as is now obtainable. The only printed
yet met with is in the *Reliquiæ Baldwinianæ*, the cor-
ıce of Dr. Wm. Baldwin (Elliott's ablest collaborator),
ədited by his friend, Dr. Darlington. By reference to
:48, 249, and 585, it is made out that the first number of
vork was issued as early as October, 1816, was recalled,
, and issued anew, along with the second number, before

January, 1817. The first number probably ended on p. 96; the second on p. 222. The third and fourth numbers were published before November 10, 1817. The fourth number must have included p. 466; the fifth and concluding number of the volume (to which the title-page assigns the date of 1821), must begin on or before p. 529. For, on the latter page Nuttall's genus *Diamorpha* occurs, and his work is for the first time cited; while the prefatory list of decandrous genera, on p. 466, does not contain *Diamorpha.*

This is confirmed by Elliott's correspondence with Zaccheus Collins, now in the possession of the Academy of Natural Sciences, Philadelphia, which Mr. Redfield has kindly consulted, at my request; from which it appears, in short, that No. 1 was first issued, September 26, 1816; No. 2, on or before February 19, 1817; No. 3, on or before April 3, 1817; No. 4 and No. 5, no data found; No. 6, the commencement of the second volume, appeared on or before October 12, 1821. The title page of this volume bears the date of 1824.

The collection referred to, and which contains a series of letters of Muhlenberg, Elliott, Bigelow, Torrey, and others, to Collins, has been put into excellent condition for preservation by Mr. John H. Redfield. A hasty perusal shows that it is replete with interest. It would be well if the Philadelphia Academy would print it, or at least portions of it, with some editorial notes which could now be supplied, but for which it may now ere long be too late. A. G.

2. *Homogone and Heterogone* (*or Homogonous and Heterogonous*) *Flowers.*—That difference in relative length or height of stamens and style, reciprocally, which in Torrey and Gray's Flora of North America, was very long ago designated by the term *diœcio-dimorphism*, Mr. Darwin—who detected and has made much of the meaning of the arrangement—called simply *dimorphism.* Besides these *dimorphic*, he also brought to view *trimorphic* flowers. The first name is too long for use, and carries with it some ambiguity, since it may imply a separation as well as a diversification of the sexes. Mr. Darwin's term has the disadvantage of not indicating what parts of the blossom are *dimorphic* (hermaphrodite flowers may be dimorphous in the perigonium), and a more generic name is now required, on account of *trimorphic*, etc. This has been supplied by Hildebrand, in Germany, who has introduced the term *heterostyled* and the counterpart *homostyled.* These are not particularly happy appellations; for the difference is in the stamens as well as in the pistil, and in the latter is not always restricted to the style. Well-established terms ought not to be superseded on the ground of mere improvement; but those which have not yet taken root sometimes may be. Following the analogy of *perigonium* or *perigone*, I propose the more exactly expressive term of *heterogone* (or *heterogonous*) for these flowers, such as those of *Primula*, *Houstonia*, *Lythrum*, etc. The counterpart, *homogone* (or *homogonous*) would designate the absence of this kind of differentiation. These terms, either in Latin or English

m, would work well in generic or specific characters, and have advantage of etymological correctness. · A. G.

. *Geographical Statistics of the European Flora.*—In a paper tributed in 1874 to the Transactions of the Historic Society of ncashire and Cheshire, Mr. Thomas Comber discussed the geo- phical statistics of the British flora. In another paper, read rch, 1875, these enquiries are extended to the rest of the flora Europe; and the dispersion considered with regard to latitude, tion, habit of growth, character of flower, nature of fruit, seed, Contrary to the common idea, the European maritime phæ- gamous plants appear to be less widely dispersed, on an aver- e, than the non-maritime. Trees and shrubs range rather more dely than herbaceous plants over land, less so over sea. Plants th creeping rootstocks or stolons are much more widely dis- rsed than those without them. The distribution of annuals, ecially of the warmer temperate species, exceeds that of peren- l herbs. Endogens are more widely spread than Exogens, etalæ than Polypetalæ, and still more than Gamopetalæ; nts with inferior ovary are more limited than those with supe- r ovary; that is, the lower and less specialized in structure are re widely distributed than the higher or more specialized. at the inconspicuously colored surpass in range those with ghtly colored and conspicuous flowers, may be regarded as other illustration of the same rule. The Cryptogams, of course, ve much the widest range. Plants with fleshy fruit considerably pass those with dry fruit in area of distribution, in the ratio of out 5 to 3. Of the dry fruits, the indehiscent belong to plants th a somewhat higher average of distribution. The curious nclusion, formerly reached from various data, is confirmed by the tistics of the European flora, namely, that *Compositæ* with ppus, on the average, are less widely distributed than those thout; and generally, that plants with special adaptations for persion of fruit or seeds, are rather less widely dispersed than se which have no such special appliances; excepting, however, coma of seeds. This, as De Candolle concludes, and Mr. Com- r confirms, is accompanied by a high degree of dispersion. ch of this probably comes from the large number of *Salices* in European flora; these being woody plants of comparatively r organization, and largely boreal. We doubt if this rule holds th *Asclepiadeæ*—the most comose-seeded of the higher orders. e species of *Asclepias* in North America are not remarkable for de range. Although number of seeds might be supposed to e advantage, yet, on the whole, the European plants with soli- y seeds have somewhat wider range than those with two or re seeds in each cell. Plants with albuminous seeds somewhat pass in range the exalbuminous. This is remarkable in view of fact that seeds of longest known vitality and which best dure exposure to sea water, are mainly exalbuminous or nearly Large genera have somewhat higher dispersion than small es; and variable species, than those not particularly variable. e laws that govern the distribution of plants are complex and condite. A. G.

4. *The Wild Flowers of America.* Illustrations by ISAAC SPRAGUE. Text by GEORGE L. GOODALE, M.D., Assistant Professor of Vegetable Physiology and Instructor of Botany in Harvard University. Part I. Boston: (Houghton & Co.) Dec. 1876. pp. 16, tab. 1–4, imp. 4to.—It is proposed to published this work in quarterly parts or numbers, and in it "to present illustrations and descriptions of all the more attractive flowering plants of America,"—meaning, no doubt, the United States, and the Atlantic portion of them, without excluding, perhaps, the Western and even the Pacific States as the work goes on. It is a large undertaking, even under the most restricted view. The want has been felt, and various futile attempts have been made to supply it. They have speedily come to nought, most of them deservedly, the few worth having because they would not pay. The only work of the kind we can now call to mind which gave fairly good figures of our wild flowers, and which was carried beyond a single part or volume, was by the late Dr. W. P. C. Barton. This was upon a plan not unlike that of the present work, perhaps equally expensive, for the figures were hand-colored, but far less sumptuous, and the figures—though really good—by no means so admirable as those by Mr. Sprague, who is almost unrivaled as a botanical draughtsman. These figures are not in the style of the North American Genera Illustrated, in which Mr. Sprague's talent in this line was first made known. The plates of that work were addressed to botanists only, are uncolored outlines, mainly valuable for their dissections and other details. These are imperial quarto plates, representing the flowers and as much of the herbage as is needed to give their part and bearing, in their natural colors, reproduced from the artist's paintings by the chromo-lithographic process. The undertaking was probably suggested by the success of this kind of work by the same artist in the colored plates of Mr. Emerson's Trees and Shrubs of Massachusetts, to which we called attention a year ago. The present work therefore addresses itself to amateurs as well as to botanists, to all lovers of flowers and admirers of beautiful works of art. From all these evidently it must have a large patronage if it is to prosper and continue. Nothing upon such a scale of excellence has ever been attempted in this country before. The plates are simply exquisite; in the typography the Riverside Press has done its best; and the letterpress not only describes the flowers represented clearly and popularly, but expatiates upon their arrangements for insect-aid in fertilization—the novel and attractive topic of the day—and adds other curious lore.

The first plate charmingly represents our wild Columbine (*Aquilegia Canadensis*); the second, our wild Cranesbill (*Geranium maculatum*); the third, Many-leaved Aster (*Aster undulatus*); the fourth, both the Yellow Gerardia (*G. flava*) and the commoner slender purple species, *G. tenuifolia.* (We take blame to ourselves for having given currency to "False Foxglove" as a popular name for the large yellow-flowered species of *Gerardia.* Gerardia makes a good popular name, and would soon become as

liar as *Magnolia* or even *Lobelia.*) "The great expense at-
ing the work requires that the price per part shall be $5.00,"
the publishers. We admire their courage in the enterprise,
in aiming at the highest attainable excellence. There are
ations that their laudable endeavors will be responded to,
that the time has at length arrived when a popular work of
kind and in this style—so creditable to all concerned in it—
be appreciated and sustained. A. G.

Report upon Geographical and Geological Explorations and
eys, west of the One-hundredth Meridian, in charge of First
tenant GEO. M. WHEELER, under the direction of Brigadier
eral A. A. Humphreys, Chief of Engineers, U. S. A. Vol. V.
ogy. Washington: Government Printing Office. 4to, 1019
with 45 plates.—This large and valuable volume is hand-
ly executed, and is in every way creditable to the officers
r whose direction it has been prepared, and to the several
ralists who have contributed reports to it. The plates
well executed, and several are colored (chromolithographs.)
ough this volume is dated 1875, and was doubtless then
ted, it appears not to have been actually published until the
r part of the summer or early in the autumn of 1876. It in-
es the following reports:
troductory Letter, by H. C. Yarrow, M.D., surgeon and natu-
t to the expedition; Notes upon Geographical Distribution
Variation, by Dr. Yarrow; Report upon the collections of
nmals, by Dr. Elliott Coues and Dr. Yarrow; Report upon
Ornithological Collections, by H. W. Henshaw; Report upon
collections of Batrachians and Reptiles, by Dr. H. C. Yarrow;
psis of the Reptiles and Batrachians of Arizona, with critical
field notes and an extensive synonymy, by Dr. Coues;
ort upon the collections of Fishes, by Prof. E. D. Cope and
Yarrow; Report upon the Hymenoptera, by E. T. Cresson,
List of Formicidæ, by Edward Norton; Reports upon the
nal Lepidoptera, by T. L. Mead and W. H. Edwards; Report
n new species of Zygænidæ and Bombycidæ, by R. H. Stretch;
ort on Diptera, by C. K. Osten-Sacken; Report upon the
optera, by Henry Ulke; Report upon the Hemiptera, by P.
Uhler; Report upon the Orthoptera, by Prof. Cyrus Thomas;
ort on the Neuroptera and Pseudo-neuroptera, by H. A. Ha-
; Report upon the terrestrial and fluviatile Mollusca, by Dr.
row; Report upon the fresh-water Leeches, by A. E. Verrill.
plates illustrate rare or novel species and varieties of birds,
iles, fishes, and insects. A. E. V.

IV. ASTRONOMY.

The secular change of Magnetic Declination in the United
es, and other parts of North America: New discussion by
RLES A. SCHOTT, Assistant U. S. C. S.—This is an exten-
of Mr. Schott's paper in the Coast Survey Report of 1859,
forms App. No. 8 of the Report for 1874. Forty-three sta-

tions are represented in the discussion, and over 400 observations. Formulæ are given for each station, with decennial tables computed therefrom. Mr. Schott says:

"A cursory examination of the column containing the epochs of greatest *easterly* excursion, the *deflecting* force producing the secular change attaining then an easterly maximum, shows that the needle became stationary in direction, and then reversed its secular motion, in the New England States toward the end of the past century, in the Atlantic coast States to the west and south early in the present, and in Mexico about the close of the first third of the present century. In California, Oregon and Washington Territory, it has not yet reached this condition. We thus have the following epochs for comparison: Halifax, about 1711; Portland, Portsmouth, Newburyport, Salem, Boston, Cambridge, Nantucket and Providence, about 1779; Hartford, New Haven, New York, Hatborough, Philadelphia, Washington and Cape Henry, about 1800; Charleston, Savannah, Key West and Havana, about 1800; New Orleans, about 1831; Vera Cruz, Mexico, Acapulco and San Blas, about 1837; San Diego, Monterey and San Francisco, expected about 1907 (yet very uncertain.)

We are thus directed to the extreme northeastern States for probable indications of what may be expected to follow on the seaboard in more southern and western States. Respecting the secular movement of the needle, apparently a little more than a century passed before the influence which produced the turning of the north end of the needle westward in Maine (increasing there the western declination), was felt in Lower California (diminishing there the eastern declination). In California, Oregon, and Washington Territory, the eastern declination is at present still *increasing*, but with a losing rate. By the time the western elongation of the secular change is reached in Maine, we may expect to see the needle in the *opposite* phase, or at its eastern elongation in California. We cannot as yet follow this influence directly over the interior of the United States for want of early observations; the westernmost interior stations for which an epoch could be made out were Buffalo, Erie, Cleveland and Detroit; these give the average turning epoch 1794. It may be quite practicable hereafter to trace out curves uniting all stations where the needle was stationary at a given epoch, and again at other epochs for regular intervals of time, say of ten or twenty-five years.

Returning to the first table, the constant in each formula would represent the normal direction of the needle about which the motion constituting the secular change would be performed in an average cycle of about two hundred and seventy years, and with extreme deflections on either side of it equal to the coefficient of the periodic term, all under the *supposition* that the law of the secular movement was truly expressed. It is no doubt much more complex, and besides may fail at any time; yet, as far as our present experience reaches, and within the interval when the first reliable observations were made to the present time, it is found trustworthy."

2. *Investigation of Corrections to Hansen's Tables of the Moon;* by S. Newcomb.—This memoir forms Part III of papers published by the Commission on the Transit of Venus. For determining the longitude of the Transit Stations from moon occultations it became necessary to determine the errors in the tables of the moon which 13 years' observations and the discussions of earlier data develop. It was already known that an unexplained correction to the moon's mean motion must be applied, that now amounts to about 10″. In addition to this and to several other corrections, Prof. Newcomb finds an empirical term necessary to satisfy observations, the form of which is,

$$1'',50 \sin. [g+21^\circ,6(Y-1865{\cdot}1)],$$

where g is the mean anomaly, and Y the date in years. This term is not yet explained in the theory of the moon.

3. *Knobel's Reference Catalogue of Astronomical Papers and Researches.*—We have received advance sheets of the Monthly Notices of the Royal Astronomical Society for November, 1876, which contains an important bibliographical paper by E. B. Knobel, F.R.A.S., with the title above. The author has selected various subjects of Stellar Astronomy, and has made nearly exhaustive indices of the various memoirs and papers relating to these published in the many astronomical and scientific periodicals and in separate treatises. The subjects chosen are: (1.) Double Stars, and the theory of Binary Systems. (2.) Variable Stars. (3.) Red Stars. (4.) Nebulæ and Clusters. (5.) Stellar proper motions. (6.) Parallax and Distance of Stars. (7.) Star Spectra. These are thoroughly and carefully indexed, Double Stars alone having over 700 references, and the rest being equally full. There are about 3,000 references in the list, and a careful examination of one section by the writer has proved its accuracy and its completeness. E. S. H.

V. Miscellaneous Scientific Intelligence.

1. *Notes on Assaying and Assay-Schemes;* by Pierre de Peyster Ricketts, E.M., Ph.D., etc. 172 pp. 8vo. New York. 1876.—Dr. Ricketts, Instructor in Charge of the Assay Laboratory of the School of Mines, Columbia College, has embodied in this work the system of assaying practiced in the school which has been developed under Dr. Chandler and his assistants. Every such treatise is sure to add something to the common stock in its department. The notes are systematic, and the assay-schemes are clearly presented and specific. B. S.

2. *Alcoholic Strength of Australian Wines.*—From the report of a commission appointed by the Governor to inquire into the alcoholic strength of South Australian wines, and printed by authority of the House of Assembly (July, 1874) at Adelaide, it appears that the amount of glucose in the mature grapes of that province ranges from 25 to 30 per cent, and produces in the wine an alcoholic strength of from 28 to 40 per cent of proof spirit.

One sample of must, prepared March 24, 1874, from the press of Hon. Samuel Davenport, at Beaumont, gave a specific gravity at 70° F. of 1·1425, which corresponds to 28·409 grams per gallon of glucose, and 20·743 per cent of absolute alcohol, or 44·522 of proof-spirit by measure.

The average of 17 samples of must, pressed from the grapes by the two analysts, Messrs. Copins and Thomas, to avoid all chance of falsification in the hands of the vintner, gave for the specific gravity 1·1179: grape-sugar, 27·259=proof-spirit, 28·419 per cent. The maximum of sugar and proof-spirit in the 17 samples examined by these two chemists was found in the juice of the Frontignan grape grown by Mr. Gillard, at Norwood, namely—sugar, 32·165; proof-spirit, 33·505.

Mr. Francis, one of the analysts, says in his report, "the natural grape juices of this colony are capable of producing very strong wines, which are more likely to exceed 26 per cent of proof-spirit than otherwise, and that the fruit contains all the elements to set up and complete fermentation to the full conversion of the sugar into alcohol without acetification."

From the colonies of Victoria and New South Wales we have a report on the alcoholic strength of 200 samples of wine, of which 38 were from the latter colony, in Albury district; 101 from Murray district, in Victoria, and the remainder from eight other wine districts of the same colony. Messrs. Moody and Heath, government inspectors of distilleries, made the determinations. They show, for New South Wales and the Murray district, a range of proof-spirit from a minimum of 20 per cent to a maximum of 34, the greater number ranging about 28.

The grapes cultivated are exclusively of European origin. The soil and climate are wonderfully well adapted to the growth of abundant fruit; but as yet the qualities of bouquet and flavor, admired in the best European wines, are feebly and often not at all developed in those of Australia made from the same grapes. Nor is the *gôut de terre*—the result of a too rank soil and growth—wanting in the Australian wines. In this respect and in intoxicating power they much resemble the wines of California. B. S.

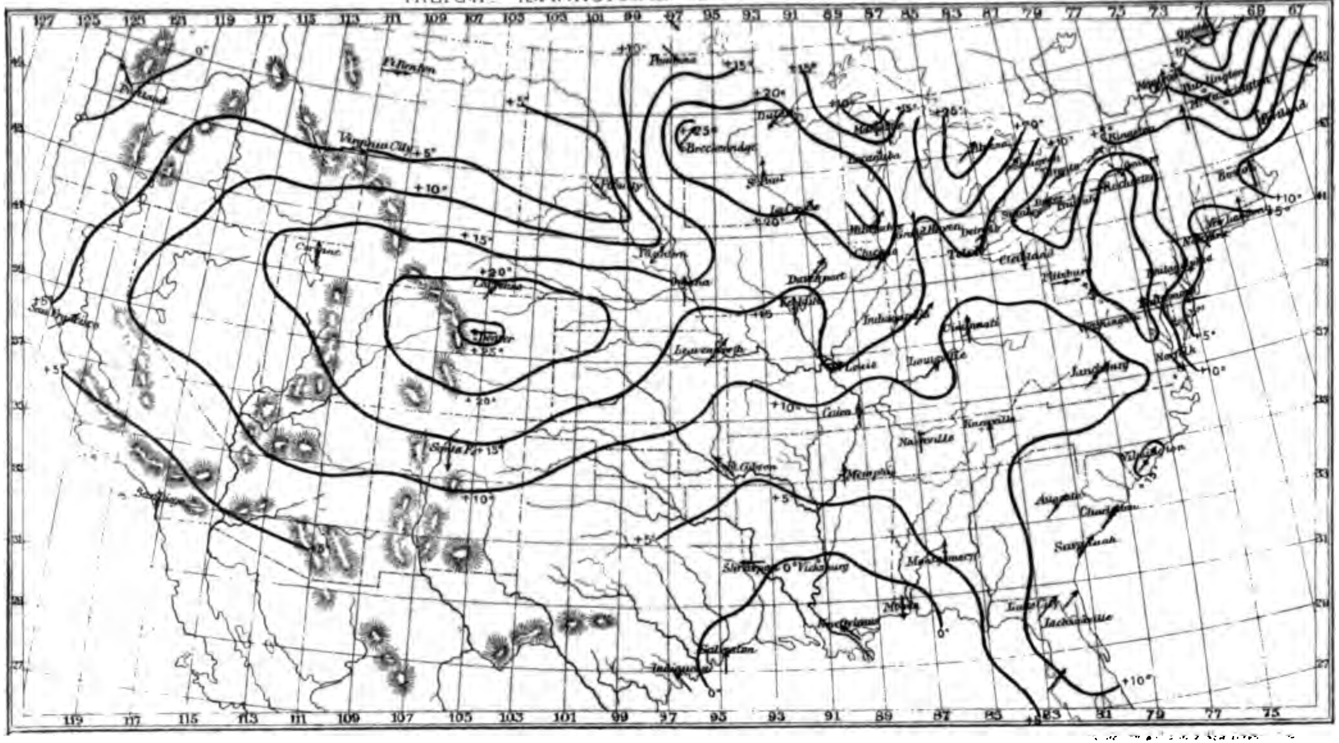
OBITUARY.

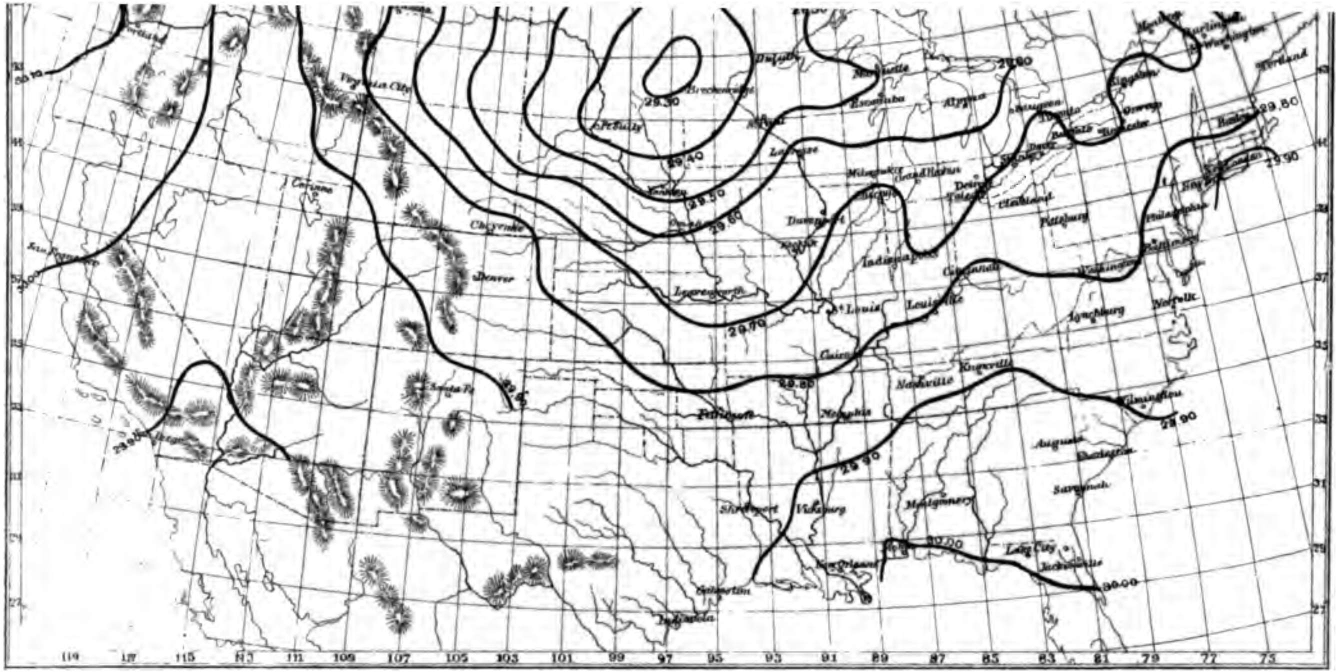
F. B. MEEK, the author of various elaborate works and memoirs on American Paleontology, died on the 22nd of December. An obituary notice is deferred to the following number.

DAVID FORBES, a learned geologist, Foreign Secretary of the Iron and Steel Institute, one of the Secretaries of the Geological Society of London, a Fellow of the Chemical and also of the Royal Society, died on the 5th of December, aged forty-eight years. He was a great traveller and resided for a while in Bolivia and Peru making researches in its mines and geology, which he afterward published.

THERMIC ISABNORMALS JUNE 18 1873 4.35 PM

PLATE I.

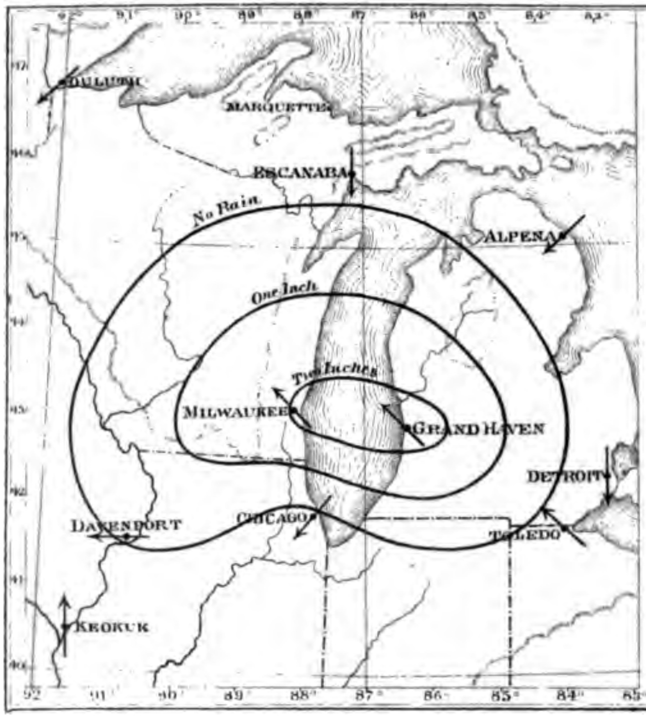




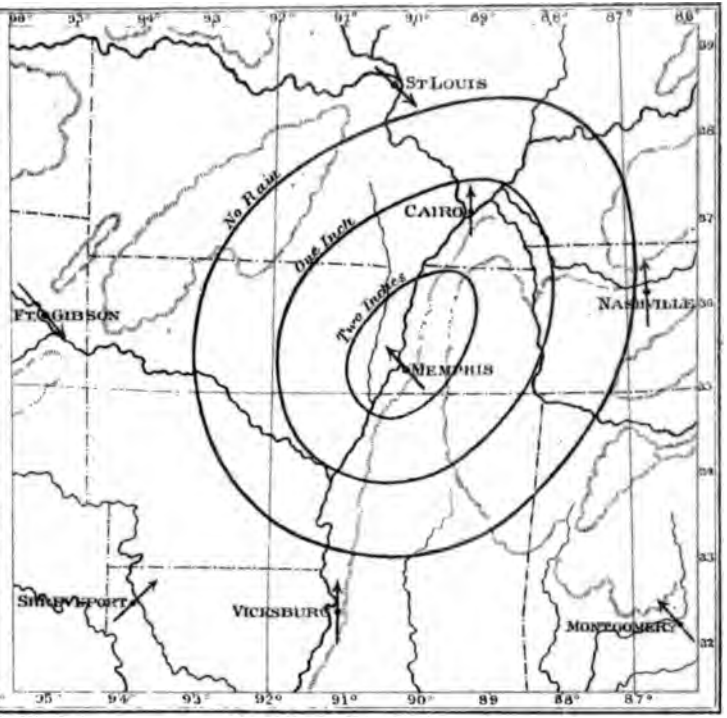
Punderson & Crisand New Haven Conn.

PLATE II

RAIN AREA SEPT 25 1872



RAIN AREA JUNE 1[illegible] 187[illegible]



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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

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ART. VIII.—*Astronomical Observations on the Atmosphere of the Rocky Mountains, made at elevations of from* 4,500 *to* 11,000 *feet, in Utah and Wyoming Territories and Colorado;* by HENRY DRAPER, M.D., Professor of Analytical Chemistry and Physiology in the University of New York.

ANYONE who observes with a large telescope soon becomes aware of the great obstacle atmospheric undulation offers to the pursuit of astronomy, particularly in the application of photography and the spectroscope. During two years when I photographed the Moon on every moonlight night at my observatory* there were only three occasions on which the air was still enough to give good results, and even then there was unsteadiness. Out of 1,500 lunar negatives only one or two were really fine pictures. A letter which the late Mr. Bond wrote to me states that in seventeen years he had never met with a perfectly faultless night at the Cambridge Observatory.

Such facts naturally cause astronomers to consider whether it is not possible to diminish atmospheric disturbances, and have led to the celebrated expeditions of Professor Piazzi Smyth to the Peak of Teneriffe and Mr. Lassell to Malta. Theoretically, it would seem that the only complete solution is to ascend high mountain ranges or isolated peaks, and leave as much as possible of the air below the telescope.

Having had occasion during the months of August and September, 1876, to go on a hunting trip with two distinguished officers of the United States Army into the Rocky Mountains and Wahsatch range, I thought it desirable to carry a telescope with a view of ascertaining whether there would be sufficient inducement to return with my twelve-inch achromatic or twenty-eight-inch reflector and make a prolonged stay. The experience which Professor Young had had at Sherman station, on the Union Pacific Railroad, left the question open, for he suffered from an unusually cloudy season, and, while he obtained very gratifying results, he seems on the whole to have been disappointed with the character of the atmosphere.

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* Professor Henry Draper's Observatory is at Hastings-on-Hudson, near New York; latitude 40° 59′ 25″; longitude 73° 52′ 25″; elevation above the sea, 225 feet.

As the region into which the party proposed to go was difficult of access and entirely without roads and much of the traveling was to be on horseback, through fallen timber and up precipitous places, it was not feasible to take an instrument of any great size. I therefore contented myself with a small achromatic of unusual excellence. Though of only one and one-quarter inches aperture, it bears a power of upwards of sixty completely, and I think would carry one hundred. It was provided with a short brass tripod, holding an altitude and azimuth movement, giving both steadiness and smoothness of action. The eye-piece was capable of adjustment by a rack and pinion, and the object glass was so arranged in its cell as to be free from injurious compression. This little lens stands the severe tests invented by Foucault, and in spite of its size is capable of doing good work.

In such observations on the atmosphere as those proposed during this trip, it is obvious that there are mainly two points to be considered: first, freedom from tremor, and second, transparency. A station which combines both is most desirable, but a marked predominance of steadiness gives special advantages for celestial photography while increase of transparency even if accompained by unsteadiness is of value in eye observations. I had been led to suppose, from conversations with Government officers and persons connected with the geological and geographical surveys of the Territories, that the Wahsatch range, which is intermediate between the Sierra Nevada on the west and the true Rocky Mountains on the east, would offer the greatest advantages. This supposition turned out to be altogether incorrect, though it might have been argued that a high range flanked at a distance on either side by other higher ranges should have given the maximum chance for cloudless and still skies.

We first went to Salt Lake City, which, according to the Casella aneroid I carried, is at an elevation of 4,650 feet above the sea. It lies at the foot of the Wahsatch range. At eleven o'clock on the evening of arrival, August 25th, I took some observations from the hotel, after carefully centering the object-glass. Saturn looked about the same as on an ordinary night at my observatory. Capella, which was just clear of the house-tops across the street, twinkled as badly both to the naked eye and in the telescope as I have ever seen it at the sea-level. Lieutenant Warren, of Camp Douglas (a military post near the city) said there had been a heavy rain the week previous and the air was more moist than usual. I had noticed that the sun set among just such a bank of clouds as we are accustomed to see in New York. I was somewhat prepared for a tremulous condition in these high regions, because, the preceding night having stopped for a few minutes at Fort Steele, on the Union Pacific Railroad, I perceived that Antares twinkled very much though we were nearly 7,000 feet above the sea.

However, in order to make a thorough trial it seemed best to ascend one of the high peaks of the Wahsatch, and accordingly the Red Butte was selected. The officers at Camp Douglas facilitated the trip in every way, furnishing horses and a guide, and the surgeon of the Post, Dr. Smart, who is an able and cientific man, accompanied me. The peak proved to be 7,350 eet high. Though it was quite clear when we started, clouds gathered in every direction as the sun went down, and at nightfall the sky was entirely overcast. Moreover, the wind blew so trongly that it was necessary to retire over the brow of the mountain, and eventually we returned to Camp Douglas. At his point, 5,250 feet above the sea and about 600 feet higher han Salt Lake City, the telescope was set up to take advantage of some breaks in the clouds, through which the Moon, Antares, ζ Ursæ Majoris and Jupiter appeared. With a power of only twenty the twinkling was surprisingly great; I do not remember ever to have seen it worse with my large instruments.

These results led to an examination into the meteorology of Salt Lake City, so as to find out the rainfall and its distribution and the percentage of cloudy days. Dr. Smart had the following copy of the post records made for me:

TABLE I.—*Rainfall and other Cloudy Days at Salt Lake City.*

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	Rain fall & melted Snow.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.
1872	1·30	..	2·60	19	1·20	..	2·04	..	2·34	16	·58	11
1873	2·18	23	1·89	19	·90	11	2·00	10	4·10	16	·24	5
1874	1·28	18	1·03	17	2·87	21	·77	16	2·89	16	·72	13
1875	2·21	31	·80	28	2·37	31	1·05	23	3·29	4	1·10	7
1876	1·22	27	·90	23	4·00	28	1·79	17	4·04	19	·14	7

TABLE I—continued.

	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	R in fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.
1872	·02	10	·72	16	·94	9	1·44	13	·66	16	2·26	15
1873	·12	7	·94	14	·42	6	·84	13	·38	10	1·20	24
1874	2·12	10	2·11	9	·30	6	1·89	27	2·26	26	1·06	27
1875	·64	14	0	6	1·15	13	1·48	18	4·54	30	2·78	31
1876	1·08	6										

From Table I, it appears that the average annual rainfall for the past five years is $18\frac{40}{100}$ inches, distributed as shown in Table II. There is no perfectly dry month, the nearest approach being during the summer. The cloudy days are 194 per annum, the disposition being similar to the rainfall.

TABLE II.

January,	1·64 inches of rain.	25 cloudy days.
February,	1·44 "	21 "
March,	2·27 "	23 "
April,	1·53 "	16 "
May,	3·33 "	14 "
June,	·56 "	9 "
July,	·80 "	9 "
August,	·94 "	11 "
September,	·70 "	8 "
October,	1·41 "	18 "
November,	1·96 "	20 "
December,	1·82 "	24 "

A former pupil of mine, and graduate of the University, Dr. Benedict, informed me that the Mormons believed the rainfall had much increased since their community had settled in Utah, and this seems to be borne out by the statement that whereas formerly three gallons of Salt Lake water produced on evaporation one gallon of salt it now takes four gallons to produce the same quantity.

On the whole it is doubtful whether there would be enough advantage in bringing a large telescope to this region to make it worth while to encounter the labor and expense.

On August 30th, having taken an escort we moved south from Fort Steele, latitude 41° 48′, longitude 107° 09′, along the north fork of the Platte River into the main range of the Rocky Mountains. During the fifteen days' expedition there were only two nights on which we saw clouds enough to prevent astronomical working, and only one thunder storm of any moment took place in our immediate vicinity; about one-quarter of an inch of rain fell. The sky was rarely perfectly free from clouds and many local thunder storms occurred about the higher peaks, but they seldom extended to the plateaus below.

September 1st and 2d our camp was 8900 feet above the sea in the vicinity of mountains rising 10,000 and 11,000 feet. These peaks seemed to be nearer than they really were, for the transparency of the air causes estimates of distance to be deceptive. From the top of one I subsequently saw the Seminole mountain which was 150 miles distant; it did not appear to be 50 miles away. The night of Sept. 1st was quite clear, with very little cloud, and the atmosphere remarkably tranquil. Antares, when near setting, hardly twinkled at all, and Arcturus in the telescope exhibited four diffraction rings unbroken by flickering. The central disc was as hard and sharply defined as the pinhole in the lamp screen I am accustomed to use in testing specula and lenses. I looked for the companion of Polaris, but partly on account of the nearly full Moon, and partly from the thickness of the diffraction rings, I could not be sure of it. The Moon was perfectly steady; with a power of 60 there was no trace of twinkling at the terminator. I tried to see Titan, the largest satellite of Saturn, but did not succeed. At the time it was not certain whether this failure was due to the position of Titan with relation to Saturn, or whether it arose from the blinding effulgence of the Moon. Capella was perfectly steady though there was a slow change of color from bluish to reddish occupying about a second.

The succeeding night at nine o'clock, though the sky was mostly covered with cumulus clouds in motion southward, I was surprised to find the terminator of the Moon absolutely free from twinkling, and Arcturus down among the tops of the dead aspen trees as steady as possible. The four diffraction rings round the central disc were not perfectly circular, but that was the fault of the lens. Every defect of centering or of surface, and any vein in the glass comes out even more clearly than in the workshop examinations, because while the air is as steady the light is far more intense.

I am certain if a large telescope could be brought here and maintained against the furious winds great results might be attained if there is much of this weather. But this particular place is difficult of access and possibly no better than other situations on the line of the railroad. The sky is not as black as I had expected; it is rather of a light blue, though the full Moon makes much difference.

On several other nights in both lower and higher places I made observations but never saw the combination of steadiness and transparency again. On the plateaus at the foot of the mountains and away from the groves of aspen trees and pines the sun sends down scorching rays all day long on the alkali plains where only sage plants are sparsely scattered, and even on horseback one can see the heated waves rising from the ground. The air is far from being moist for the lips are apt to crack and bleed, and the mucous membrane of the nose is parched. When the sun sets the ground radiates rapidly, and we frequently had by morning one-quarter of an inch of ice in our vessels of water standing outside the tents. These plateaus are on an average about 7250 feet above the sea. The mere fact of broken ground and wooded surroundings does not however suffice to produce, even at this season, a tranquil air, for when we rode over the Rocky Mountains along the margin of perpetual snow to the headwaters of Snake River, and camped at Trout Lake nearly 10,000 feet high, though the air was exceedingly transparent it was very unsteady. I rose at four A. M. to see Venus, and her splendor was so great that it led to a most delusive estimate of her apparent size. Occasionally during clear frosty weather in midwinter a night of similar characteristics is seen at my observatory. On such an occasion I obtained at the principal focus of the 15½-inch reflector a photograph of the Moon near her third quarter in less than a second.

The officers of Fort Steele and the guides say it would be impossible to do any astronomical work in this region from the middle of October till the middle of May, that is, for seven months. The fierce winds, heavy falls of snow and intense cold would be unbearable. Even in the beginning of September we needed large camp fires in the morning and evening. Our camp at Trout Lake could only be reached for six weeks in summer on account of the depth of snow in the fallen timber.

On the whole it may be remarked of this mountain region that the astronomical condition, particularly for photographic researches, is unpromising. In only one place were steadiness and transparency combined, and only two nights out of fifteen at the best season of the year were exceptionally fine. The transparency was almost always much more marked than at the sea level, but the tremulousness was as great or even greater than near New York. It is certain that during more than half the year no work of a delicate character could be done. At the end of August in sheltered positions, and in good tents, we slept under half a dozen thicknesses of blanket and only partially undressed. Such a degree of cold distracts the mind and numbs the body. Apparently, therefore, judging from present information, it would not be judicious to move a large telescope and physical observatory into these mountains with the hope of doing continuous work under the most favorable circumstances.

RT. IX.—*Photographs of the Spectra of Venus and α Lyræ.* Note by Prof. Henry Draper, M.D.*

SINCE the spring of 1872 I have been making photographs of e spectra of the stars, planets and Moon, and particularly, ong the stars, of α Lyræ and α Aquilæ with my 28-inch flector and 12-inch refractor. In the photograph of α Lyræ, nds or broad lines are visible in the violet and ultra-violet gion unlike anything in the solar spectrum. The research is ficult and consumes time, because long exposures are neces-ry to impress the sensitive plate, and the atmosphere is rarely the best condition. The image of a star or planet must be pt motionless for from ten to twenty minutes, and hence the iving clock of the telescope is severely taxed.

During last summer I obtained good results, and in October ok photographs of the spectrum of Venus, which show a large mber of lines. I am now studying these pictures, and have bmitted them to the inspection of several of my scientific ends, among others Professors Barker, Langley, Morton and lliman. There seems to be in the case of Venus a weakening the spectrum toward H and above that line, of the same char-ter as that I have photographically observed to take place in e spectrum of the Sun near sunset.

ew York, December, 1876.

RT. X.—*On Dinitroparadibrombenzols and their Derivatives;* by Dr. Peter Townsend Austen. Second Paper.

THE separation of the three isomeric dinitroparadibromben-ls I have already described in a previous paper.†

The residue from the separation of the α- and β-isomers nsisted, for the most part, of β-dinitroparadibrombenzols, ich forms the chief product of the nitrition. These resi-es were collected and, after several crystallizations from car-n disulphide, were recrystallized from glacial acetic acid. fter six crystallizations, the fusing point remained constant.

Betadinitroparadibrombenzol.

The betadinitroparadibrombenzol crystallizes from its solu-n in carbon disulphide in thick white pointed and peculiarly nt needles. It is very easily soluble in the usual solvents, especially in glacial acetic acid, carbon disulphide, acetic ether,[*] alcohol, etc.

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* This article was printed on the third page of the cover of the January num-, and is here reproduced without change.—EDS.

† This Journal, vol. xii, 118, 1876.

It fuses at 99°–100°[†] to a yellowish liquid. 0·2940 grms of substance gave 0·0330 grms. of H^2O, and 0·2418 grms. of CO^2.

Calculated for $C^6H^2(NO^2)^2Br^2$.	Found.[‡]
$C=22·08$	22·43
$H=0·61$	1·24

The compound is somewhat volatile. Inspiration of its vapors occasions an intense inflammation of the mucous membranes. An alcoholic solution, when brought upon the skin, excites itching, smarting, and inflammation accompanied by subsequent peeling off of the skin. A minute quantity brought in contact with the eye causes a sharp pain lasting several days. On the more sensitive skin of the face it gives rise to a smart which, after it has attained a maximum, suddenly vanishes. It is hence a powerful excitant.

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[*] It is very striking that nearly all substances which are soluble in glacial acetic acid, are also soluble in acetic ether.

[†] In a preliminary notice I gave the fusing point as 120°. The substance was not quite free from the isomeric compounds. The separation of the last traces of the isomers is exceedingly difficult. The greatest care is also necessary in the determinations of the fusing points, for the substance which fused at 120° retained the same fusing point even after four crystallizations from glacial acetic acid. A single crystallization from alcohol, however, sufficed to prove it a mixture. In a similar manner a mixture of substances, with which I have recently been working, retained an exact fusing point of 195° during seven crystallizations from glacial acetic acid, while two crystallizations from alcohol proved that two-thirds of the mixture consisted of a substance fusing at 136°.

[‡] I have rarely analyzed a substance which was so refractory during combustion as this betadinitroparadibrombenzol. All attempts at burning it with copper oxide or lead chromate failed owing to the sublimation of the substance to the upper part of the tube, from which the highest attainable heat of the combustion furnace was inadequate to dislodge it. In making the combustions of this compound, as well as of many other substances encountered in this investigation, I have used a variation of the ordinary method of combustion, which has of late found an extended application in the analysis of refractory organic substances. It was suggested to me by Mr. Bauermeister of the Berlin University laboratory. I have employed it, in most cases, in preference to combustion in a stream of oxygen gas. Copper oxide, in the form of spiculæ (length about 10mm., diameter about 1 to 2mm.) having been first introduced into the tube, the substance is well mixed in a mortar with lead chromate to which its equal volume of the copper oxide is afterwards added, and the whole again well mixed. After introducing the mixture into the tube, the mortar is well washed out with a mixture of oxide and chromate (equal parts) and the washings added to the contents of the tube. The tube is then filled up with chromate, leaving room for a copper spiral, in case the substance to be analyzed contains nitrogen, and rapped on the pointed end so that the contents may compact. This having been accomplished, the tube is rapped longitudinally. The heavy pulverulent lead chromate sinks to the bottom leaving the channel filled with a net-work of copper spiculæ. The gases have to pass through this net-work and are hence exposed to a very great oxidizing surface. Loss by sublimation is entirely avoided, since the substance must necessarily be deposited on the spiculæ and by them be completely oxidized. In case the compound contains haloid elements, about two inches of the lead chromate nearest the cork end of the tube must be kept just off the red heat ("black") so as to prevent any of the haloid copper compounds, which may be formed, from passing into the potash bulbs.

Betadinitroparabromaniline.

By heating the betadinitroparadibrombenzol with alcoholic ammonia for eight hours in a closed tube at 100°, I obtained a deep red solution, from which a large mass of red scales separated on cooling. The solution was poured into cold water, and the resulting yellow precipitate dissolved in boiling absolute alcohol which contained animal charcoal, filtered, and allowed to stand. The pure substance obtained in this manner formed orange-red scales fusing at 160°.*

0·3010 grms. of substance gave 0·0506 grms. of H^2O and 0·3044 grms. of CO^2.

0·24 grms., after the method of Carius, gave 0·148 grms. of AgBr and 0·0027 grms. of Ag.

Calculated for $C^6H^3(NO^2)^2NH^2Br$.	Found.	
	I.	II.
C = 27·48	27·58	-----
H = 1·52	1·86	-----
Br = 30·53	----	30·90

The substance is easily soluble in boiling alcohol and glacial acetic acid. It is almost insoluble in water, and entirely so in carbon disulphide.

It is not acted upon by boiling amyl nitrite, although in a closed tube at 100° the substances react. No defined product was obtained, which, however, was more probably owing to the small amount of substance used than to the absence of a dinitrobrombenzol.

Strong alcoholic ammonia remained at 200° without action upon it. This, however, was not surprising, since, according to Meyer and Wurster,† only one bromine atom of the mononitroparadibrombenzol can be substituted by direct action of ammonia. A somewhat similar case is recorded by Armstrong.‡ He found that the chlorine atom of dinitrochlorphenol was not affected by ammonia. The weakening action of the nitro-groups may, perhaps, here be overcome by the formation of the ammonium salt.

When boiled with alcoholic potash the substance evolves ammonia, but the nitro-groups appear to be affected, and a general decomposition is the result.

Betadinitroparabromanilidobenzol.

On treating the betadinitroparadibrombenzol with aniline, the mass assumed a fine red color. On heating a violent reaction ensued, and the mixture boiled of itself. The solution was allowed to cool, and then treated with dilute chlorhydric acid. An oil separated and gradually solidified. The dark violet mass was several times well washed with water, and then dissolved in boiling absolute alcohol containing animal charcoal, filtered, and allowed to crystallize. The substance forms superb orange-red fine hairy needles fusing at 120°. They are soluble in boiling glacial acetic acid and in alcohol.

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* It is worthy of notice that the fusing point of this compound (160°) is nearly the same as that of the alphadinitroparadibrombenzol (159°).

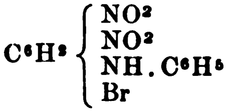
† Ber. d. d. chem. Ges., v, 632.

‡ Chem. Soc. J., (2), x, 12.

0·2885 grms. of substance gave 0·0684 grms. of H^2O and 0·4444 grms. of CO^2.

0·1685 grms. after the method of Carius gave 0·0910 grms. of AgBr and 0·0016 grms. of Ag.

Calculated from the formula—



$$C^6H^2\left\{\begin{array}{l}NO^2\\NO^2\\NH.C^6H^5\\Br\end{array}\right.$$

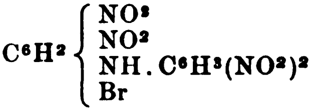
Theory.	Found. I.	Found. II.
C =42·60	42·64	....
H = 2·36	2·67	....
Br=23·66	....	23·56

Betadinitroparabromdinitroanilidobenzol.

The preceding compound was added in small portions to fuming nitric acid at a temperature of +12°. It dissolved quickly with a weak action, the color of the solution becoming darker. The resulting solution was poured into cold water, and the bright yellow powder which separated was crystallized from boiling glacial acetic acid. The substance forms small brownish yellow scales, which fuse at 167·5°.

0·2057 grms. of substance after the method of Carius gave 0·0552 grms. of AgBr and 0·0035 grms. of Ag.

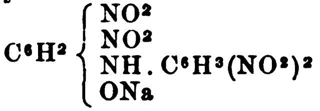
The formula—



$$C^6H^2\left\{\begin{array}{l}NO^2\\NO^2\\NH.C^6H^3(NO^2)^2\\Br\end{array}\right.$$

requires 18·69 Br; 18·81 was found.

The compound is easily soluble in boiling glacial acetic acid, but with difficulty in alcohol. If it be warmed with a solution of sodic hydrate, it forms immediately a deep blood red solution, from which, after a few minutes have elapsed, the separation of glittering red and green dichroic needles takes place. This compound I take to be a sodium betadinitroparadinitroanilidophenylate—



$$C^6H^2\left\{\begin{array}{l}NO^2\\NO^2\\NH.C^6H^3(NO^2)^2\\ONa\end{array}\right.$$

University Laboratory of Berlin, July 15, 1876.

ART. XI.—*On some Points in connection with Vegetation* ; by Dr. J. H. GILBERT.

[Continued from page 32.]

Amount of nitrogen assimilated by plants.—Let us now recur to the question of the various amounts of nitrogen assimilated over a given area by plants of different natural orders, and call attention to the facts bearing upon the point which these experiments on the mixed herbage of grass land have supplied.

TABLE IV.—*Yield of Nitrogen in the Mixed Herbage of Permanent Grass land at Rothamsted.*

Plots.	Conditions of Manuring.	Average Produce per acre per annum, 20 years, 1856–1875, according to Mean per cent at 6 periods 1862, '67, '71, '72, '74, '75.			Average nitrogen per Acre per annum.		
		Gramineæ.	Leguminosæ.	Other Orders.	10 years 1856–1865	10 years 1866–1875	20 years 1856–1875
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3	Unmanured	1635	219	529	35·1	30·9	33·0
4-1	Superphosphate*	1671	149	673	35·7	31·5	33·6
8	Complex Min. Manure.†	2442	296	639	54·4	38·1	46·3
7	Complex Min. Manure.‡	2579	806	573	55·2	56·0	55·6

In Table IV. is shown the average produce (in the condition of hay) in lbs., per acre, per annum, over twenty years, of herbage of the gramineous family, of herbage of the leguminous family, and of herbage of other orders, calculated according to the mean percentage of each of these, determined in separations at six periods, namely, in 1862, 1867, 1871, 1872, 1874, and 1875, in samples of the produce of four of the plots which have received no nitrogenous manure from the commencement; and there is also given, by the side of these results, the average annual yield of nitrogen per acre over the first ten, the second ten, and the total period of twenty years, in each case.

The quantities of nitrogen yielded are calculated from the results of actual determinations of the nitrogen in the mixed produce of the respective plots; but the estimates of the quantity of the produce referable to the different Natural Orders must be taken as only giving a general indication or an approximation to the truth; for, while the amount of the total mixed produce is the average of that of the twenty years, the amount of it referred to the different orders is calculated upon their percentage determined in six years only, four of which are among the last five, and the fluctuation according to season is in some cases very considerable, while in others there is a progression in the changes, which render an accurate estimate of the average botanical composition of the herbage over the whole period impossible. The figures do, however, undoubtedly represent the truth sufficiently nearly for our present purpose. But before referring to the yield of nitrogen, it may be remarked, in passing, how much greater is the increase of gramineous produce by the use of purely mineral manures in this mixed herbage than in the case of gramineous crops grown separately. The interesting question arises, how far the result is due to the direct action of the mineral manures in enabling the grasses to form much more stem and seed—that is, the better to manure—which, as a matter of fact, they are found to do? or how far the increased growth is to be explained by an increased accumulation of combined nitrogen available for the grasses in the upper layers of the soil, as the result of the increased growth of the Leguminosæ induced by the potass-manure, as already illustrated by the results obtained in alternating clover and barley, and in an actual course of rotation?

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* Mean of four separations only, namely, 1862, 1867, 1872 and 1875.

† Including potass six years, 1856–1861; without potass, fourteen years, 1862–1875.

‡ Including potass twenty years, 1856–1875.

Referring to the yield of nitrogen, it is seen that, without manure, it has diminished during the last as compared with the first ten years; but that the average is thirty-three pounds per acre, per annum, or considerably more than with a gramineous crop grown separately.

With super-phosphate of lime alone, the yield of nitrogen over the first ten, the second ten, and the twenty years, is very nearly the same as without manure. It is slightly higher as is also the total amount of produce; but while the quantity contributed by gramineous species is rather more, that yielded by leguminous species is less, and that by species belonging to other orders more than without manure.

With super-phosphate of lime, and sulphates of potass, soda and magnesia, during the first six years, but no potass during the last fourteen years (plot 8), the amount of both gramineous and leguminous herbage is very much increased; and that of the leguminous produce was especially so during the earlier years. The result is a yield of 55·4 lbs. of nitrogen per acre, per annum, over the first ten years, of only 38·1 lbs. over the second ten years, and of 46·3 lbs. over the twenty years.

With the complex mineral manure, including potass each year throughout the period of twenty years (plot 7), leguminous species contribute about one-fifth of the whole produce, or very much more than in either of the other cases. The result is an annual yield of 55·2 lbs. of nitrogen over the first ten years; of even slightly more, or fifty-six lbs., over the second ten years: and of 55·6 lbs. over the whole period of twenty years—that is, considerably more than twice as much as would be yielded by a gramineous crop grown separately on arable land. It may here be observed that, while in the case of the first three plots referred to, the produce of the mixed herbage diminished over the second as compared with the first ten years, that of plot 7, with the potass manure, and so much leguminous herbage, increased slightly over the second compared with the first ten years. Finally, it may be remarked on this point, how comparatively uniform is the average yield of produce by all other species other than the gramineous and the leguminous on the four very differently manured plots.

Here again, then, the results relating to the growth of species of many different natural orders growing together, like those relating to the growth of individual species grown separately, show that those of the leguminous family, and probably those of various other orders also, have the capacity of assimilating much more nitrogen over a given area than species of the order Gramineæ.

Assuming for the sake of argument that the yield of nitrogen by the Gramineæ grown separately may be explained, as already suggested, by reference to the amount of combined nitrogen acquired from the measured aqueous deposits from the atmosphere, together with that condensed within the pores of the soil, and that derived from previous accumulations within it, the question arises, can the greatly increased yield by other plants be so accounted for? or, if not, how otherwise may it be explained? We will endeavor to weigh the evidence bearing upon this point.

Is the combined nitrogen in the atmosphere the source of the assimilated nitrogen?—It so happens that the plants which do gather, or which have been supposed to gather nitrogen more readily than the Gramineæ, have obviously a different character of foliage; as, for instance, the "root crops"—turnips and the like; and the leguminous crops—beans, peas, clover, etc. An obvious explanation, therefore, which will be found in books of authority, is that these so distinguished "broad-leaved plants" have the power of taking up nitrogen in some form from the atmosphere, in a degree, or in a manner, not possessed by the narrow-leaved gramineous plants. It is true that Adolph Mayer in Germany, and Schlösing in France, have experimentally shown that plants can take up nitrogen by their leaves from ammonia supplied to them in the ambient atmosphere. But I think I am right in saying that the conclusion of both of these experimenters is that this action takes place in a very immaterial degree in natural vegetation.

In reference to this subject, I may observe that the results of the determinations of the ammonia in the atmosphere by different experimenters, and in different localities, vary very greatly; and it may be concluded that a shower of rain will wash out much of it. According to M. Schlösing's statement of the results of his recent determinations of the ammonia in the air of Paris (Compt. Rend., lxxxi, p. 1252 et seq.), it ranges from one part in about 12,500,000, to one part in about 260,000,000 of air by weight. If, for the purpose of illustration, we assume that, on the average, the ambient atmosphere in the open country—in Europe, at any rate—will contain one part of ammonia in 60,000,000 of air, or one part of nitrogen as ammonia in about 50,000,000 of air, the atmosphere would thus contain more than 8,000 times less nitrogen as ammonia than carbon as carbonic acid. But cereal crops contain one part of nitrogen to about thirty of carbon, and leguminous crops, one of nitrogen to fifteen, or fewer, of carbon. On these assumptions, the ambient atmosphere would contain a proportion of nitrogen as ammonia, to carbon as carbonic acid, about 267 times less than that of nitrogen to carbon in cereal produce, and about 534 times (or more) less than that in leguminous produce. It is true that water would absorb very much more nitrogen as ammonia, or dissolve very much more as carbonate or bi-carbonate of ammonia, than it would of carbon as carbonic acid under equal circumstances. Hence, there would appear to be a compensating quality for the small actual and relative amount of nitrogen as ammonia in the atmosphere, in the greater solubility or absorbability of the compounds in which nitrogen exists, than of the carbonic acid in which the carbon is presented. Further, it can hardly be to merely a greater extent of leaf or above-ground surface that the result could be attributed. Thus, though a bean and a wheat crop may yield about equal amounts of dry matter per acre, the bean produce would contain from two to three times more nitrogen, and approximate measurements show that a wheat plant offers a greater external superfices in relation to a given weight of dry substance than a bean plant, and greater still therefore in relation to a given amount of nitrogen fixed. If, then, the bean can in some way take up more nitrogen from the atmosphere than the wheat, the result must be due to character and function, rather than to mere extent of surface above ground. It may, however, be observed that, as a rule, even those of the leguminous crops which are grown for their ripened seed, maintain their green and succulent surface, over a more extended period of the season of active growth, than do the gramineous corn crops.

It may safely be asserted, then, that neither direct experimental evidence, nor a consideration of the chemistry and the physics of the subject, would lead to the conclusion that the plants which assimilate more nitrogen over a given area than others, do so by virtue of a greater power of absorbing by their leaves combined nitrogen from the atmosphere in the form of ammonia. And here it may be said in passing that the argument would be still stronger against the supposition that nitric acid in the atmosphere supplies directly to the leaves of plants any important amount of the nitrogen they assimilate.

But apart from the more purely scientific considerations bearing upon the question, we believe that our statistics of nitrogen-production are themselves sufficient to justify the conclusion that, at any rate, the "broad-leaved" *root-crops*, turnips and the like, to which the function has with the most confidence been attributed, do not take up any important proportion of their nitrogen by their leaves from combined nitrogen in the atmosphere. Thus, it has already been shown, that the yield of nitrogen in these crops, even with the aid of complex mineral manures, was in the later years reduced to a lower point than that in any other crop; the percentage of nitrogen in the upper layers of the soil was also reduced to a lower point than with any other crop. The evidence of this kind is, however, admittedly not so conclusive in regard especially to plants of the leguminous family.

Is the free nitrogen of the atmosphere the source of the assimilated nitrogen?—But as about four-fifths of the atmosphere which surrounds the leaves of plants consist of free nitrogen, why should not this be a source to them of the nitrogen they require? To assume that it is so is such an obvious and easy way out of so many difficulties, that this assumption has from time to time been freely made, and much experimental investigation has been undertaken on the point with the most conflicting results. It is now nearly forty years since Boussingault showed that there was a greater assimilation of nitrogen over a given area in a rotation of crops than he could well account for; and almost from that time to this he has been occupied with investigations of very various kinds, sometimes on the atmosphere, sometimes on meteoric waters, sometimes on plants, and sometimes on soils, the main object of which has obviously been to throw light on the question of the sources of the nitrogen of vegetation. And almost for as long a period as Boussingault, Mr. Lawes and myself have devoted much thought and investigation to the same end.

On this point, of whether or not plants assimilate the free nitrogen of the atmosphere, leaving out of view, for lack of time and space, the experiments and conclusions of several others who have worked on the subject on a less comprehensive scale, I will first briefly direct attention to the most comprehensive series of experiments, the results of which led the author to conclude that the free nitrogen of the atmosphere is taken up and assimilated by the leaves of plants.

During the years 1849, 1850, 1851, 1852, 1854, 1855, and 1856, M. G. Ville, of Paris, made numerous experiments on this subject. His plants were generally enclosed in a glass case, and his soils consisted of washed and ignited sand, sand and brick, or sand and charcoal. They were sometimes supplied with a current of unwashed air, sometimes with a current of washed air, and they were sometimes in free air; sometimes a known quantity of ammonia was supplied to the air of the apparatus, and sometimes known quantities of nitrate were supplied to the soil. Lastly, a great variety of plants were experimented upon. M. G. Ville's results are summarized in Table V, below.

TABLE V.—*Summary of the Results of* M. G. VILLE'S *Experiments, to determine whether Plants assimilate free Nitrogen.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, and Air; and Manure, if any.	In Products.	Gain or Loss.	
1849: *Current of unwashed air supplying* 0·001 *grams Nitrogen as Ammonia.**				
Cress	0·0260	0·1470	0·1210	5·6
Large Lupins	0·0640	0·0640	0·0000	1·0
Small Lupins	0·0640	0·0470	−0·0170	0·7
	0·1550	0·2580	0·1030	1·7
1850: *Current of unwashed air supplying* 0·0017 *grams Nitrogen as Ammonia.**				
Colza (plants)	0·0260	1·0700	1·0440	41·1
Wheat	0·0160	0·0310	0·0150	1·9
Rye	0·0130	0·0370	0·0240	2·8
Maize	0·0290	0·1380	0·0990	4·4
	0·0857	1·2660	1·1803	14·8
1851: *Current of washed air.**				
Sunflower	0·0050	0·1570	0·1520	31·4
Tobacco	0·0040	0·1750	0·1710	43·7
Tobacco	0·0040	0·1620	0·1580	40·5

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* Recherches Expérimentales sur la Végétation, par M. Georges Ville. Paris, 1853.

TABLE V.—*Continued.*

PLANTS.	Nitrogen—Grams. In Seed, and Air; and Manure, if any.	 In Products.	 Gain or Loss.	Nitrogen in Products to 1 Supplied.
1852: *Current of washed air.**				
mn Colza	0·0480	0·2260	0·1780	4·7
g Wheat	0·0290	0·0650	0·0360	2·2
lower	0·0160	0·4080	0·3920	25·5
mer Colza	0·1730	0·5950	0·4220	3·4
mer Colza	0·1050	0·7010	0·5960	6·7
1854: *Current of washed air (under superintendence of a Commission).*				
s	0·0099	0·0097	−0·0002	1·0
s	0·0038	0·0530	0·0492	13·9
s	0·0039	0·0110	0·0071	2·8
54: *Current of washed air (closed, under superintendence of a Commission).*†				
s	0·0063	0·0350	0·0287	5·6
1855 and 1856: *In free air, with* 0·5 *grams Nitre* =0·069 *Nitrogen.*‡				
a	0·0700	0·0700§	0·0000	1·0
a	0·0700	0·0660§	−0·0040	0·9
a	0·0700	0·0680§	−0·0020	1·0
1855 and 1856: *In free air, with* 1 *gram Nitre* =0·138 *Nitrogen.*‡				
s	0·1400	0·1970§	0·0570	1·41
s	0·1400	0·3740§	0·2340	1·67
s	0·1400	0·2160§	0·0760	1·54
s	0·1400	0·2500§	0·1100	1·79
1856: *In free air, with* 0·792 *grams Nitre* =0·110 *Nitrogen.**				
at	0·1260	0·2180§	0·0920	1·7
at	0·1260	0·2240§	0·0980	1·8
1855: *In free air, with* 1·72 *grams Nitre* =0·238 *Nitrogen.**				
at	0·2590	0·3080§	0·0490	1·2
1856: *In free air, with* 1·765 *grams Nitre* =0·244 *Nitrogen.**				
t	0·2650	0·2170§	−0·0480	0·8
t	0·2650	0·3500§	+0·0850	1·3

echerches Expérimentales sur la Végétation, par M. Georges Ville. Paris,

ompt. rend., 1855. ‡ Recherches Expérimentales sur la Végétation, 1857.
n plants only.

We have already discussed the results of M. G. Ville, as well as those of others, in a paper published in the Philosophical Transactions for 1859, and in a somewhat condensed form in the Journal of the Chemical Society, vol. xvi, 1863; and we can only very briefly refer to them in this place. The column of actual gain or loss of nitrogen is seen to show in one case a gain of more than one gram of nitrogen; the amount of it in the products being more than forty-one fold that supplied as combined nitrogen in the seed, and air. This result was obtained with colza. Those obtained with wheat, rye, or maize, showed very much less of both actual and proportional gain. Experiments with sunflower and tobacco showed a less actual gain than that with colza; but still it amounted in one case, with sunflower, to more than thirty, and in two, with tobacco, to more than forty-fold of that supplied. In M. G. Ville's experiments (as a glance down the last two columns in the table will show), although he still had generally some gain, it was usually both actually and in proportion to the quantity supplied considerably less than in his earlier ones.

M. G. Ville attributed the gain, in some cases, to the large leaf-surface. In explanation of the assimilation of free nitrogen by plants, he calls attention to the fact that nascent hydrogen is said to give ammonia, and nascent oxygen nitric acid, with free nitrogen, and he asks, "Why should not the nitrogen in the juices of the plant combine with the nascent carbon and oxygen in the leaves?" He refers to the supposition of M. De Luca, that the nitrogen of the air combines with the nascent oxygen given off by the leaves of plants, and to the fact that the juice of some plants (mushrooms) has been observed to ozonize the oxygen of the air, and he asks, "Is it not probable, then, that the nitrogen dissolved in the juices will submit to the action of the ozonized oxygen with which it is mixed, when we bear in mind that the juices contain alkalies, and penetrate tissues, the porosity of which exceeds that of spongy platinum?"

The experiments of M. Boussingault, and of ourselves, on the other hand, have not given an affirmative answer to the question whether plants, by their leaves, take up and assimilate free nitrogen of the air.

M. Boussingault commenced his experiments on this subject in 1837, and Table VI, which follows, summarizes his results, obtained at intervals from that date up to 1858.

s VI.—*Summary of the Results of* M. BOUSSINGAULT'S *Experiments, to determine whether Plants assimilate free Nitrogen.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, or Plants; and Manure, if any.	In Products.	Gain or Loss.	
1837: *Burnt soil, distilled water, free air, in closed summer-house.**				
il	0·1100	0·1200	+0 0100	1·09
il	0·1140	0·1560	+0·0420	1·37
at	0·0430	0·0400	−0·0030	0·93
at	0·0570	0·0600	+0·0030	1·05
1838: *Conditions as in* 1837.†				
	0·0460	0·1010	+0·0550	2·20
il (Plants)	0·0330	0·0560	+0·0230	1·70
(Plants)	0·0590	0·0530	−0·0060	0·90
and '52: *Washed and ignited pumice with ashes, distilled water, limited air, under glass shade, with Carbonic Acid.*‡				
ot, 1851	0·0349	0·0340	−0·0009	0·97
1851	0·0078	0·0067	−0·0011	0·86
ot, 1852	0·0210	0·0189	−0·0021	0·90
ot, 1852	0·0245	0·0226	−0·0019	0·92
1852	0·0031	0·0030	−0·0001	0·97
***Prepared pumice, or burnt brick, with ashes, distilled water, limited air, in glass globe, with Carbonic Acid.*‡**				
e Lupin	0·0480	0·0483	+0·0003	1·01
e Lupin	0·1282	0·1246	−0·0036	0·97
e Lupin	0·0349	0·0339	−0·0010	0·97
e Lupin	0·0200	0·0204	+0·0004	1·02
e Lupin	0·0399	0·0397	−0·0002	1·00
f Haricot	0·0354	0·0360	+0·0006	1·02
f Haricot	0·0298	0·0277	−0·0021	0·93
en Cress	0·0013	0·0013	0·0000	1·00
e Lupin	0·1827	0·1697	−0·0130	0·93
***Prepared pumice with ashes, distilled water, current of washed air, and Carbonic Acid, in glazed case.*§**				
a	0·0196	0·0187	−0·0009	0.95
f Haricot	0·0322	0·0325	+0·0003	1·01
f Haricot	0·0335	0·0341	+0·0006	1·02
f Haricot	0·0339	0·0329	−0·0010	0·97
f Haricot	0·0676	0·0666	−0·0010	0·99
a	0·0180	0·0334	−0·0021	0.94
a	0·0175			
	0·0046	0·0052	+0·0006	1·13

.nn. Ch. Phys., II, lxvii, (1838).

† Ibid., lxix.

.nn. Ch. Phys., III, xli, (1854).

§ Ann. Ch. Phys., III, xliii, (1855).

TABLE VI.—*Continued.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, or Plants; and Manure, if any.	In Products.	Gain or Loss.	
1851, '52, '53, and '54: *Prepared soil, or pumice with ashes; distilled water, free air, under glazed case.*[*]				
Haricot (dwarf), 1851	0·0349	0·0380	+0·0031	1·09
Haricot, 1852	0·0213	0·0238	+0·0025	1·12
Haricot, 1853	0·0293	0·0270	−0·0023	0·92
Haricot (dwarf), 1854	0·0318	0·0350	+0·0032	1·10
Lupin (white), 1853	0·0214	0·0256	+0·0042	1·20
Lupin, 1854	0·0199	0·0229	+0·0039	1·15
Lupin, 1854	0·0376	0·0387	+0·0020	1·05
Oats, 1852	0·0031	0·0041	+0·0010	1·32
Wheat, 1853	0·0064	0·0075	+0·0011	1·17
Garden Cress, 1854	0·0259	0·0272	+0·0013	1·05
1858: *Nitrate of Potassium as Manure.*[†]				
Helianthus	0·0144[‡] 0·0255[‡]	0·0130 0·0245	−0·0014 −0·0010	0·90 0·96

M. Boussingault's soils consisted of burnt soil, washed and ignited pumice, or burnt brick; his experiments were sometimes in free air, sometimes in a closed vessel with limited air, sometimes with a current of washed air, and sometimes in free air, but under a glass case. When the plants were enclosed, a supply of carbonic acid was provided, and in a few cases known quantities of nitre were supplied as manure.

The last two columns of Table VI show the actual and proportional gain of nitrogen in M. Boussingault's experiments. It will be observed that in his earliest experiments, those in free air, in a summer-house, the leguminous plants, trefoil and peas, did indicate a notable gain of nitrogen; but in all his subsequent experiments there was generally either a slight loss, or, if a gain, it was represented in only fractions, or low units, of milligrams. After twenty years of varied and laborious investigation of the subject, M. Boussingault concluded that plants have not the power of taking up and assimilating the free nitrogen of the atmosphere.

Our own experiments on this subject were commenced in 1857, and the late Dr. Pugh, of the Pennsylvania State Agricultural College, devoted between two and three years to the investigation at Rothamsted. Mr. Lawes has contributed one complete set of the apparatus employed to this exhibition. The arrangement, and the results obtained up to that date, are fully described in the papers already referred to, published in the Philosophical Transactions for 1859, and in the Journal of the Chemical Society in 1863. They may be briefly described as follows:—

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[*] Ann. Ch. Phys., Sér. III, xliii, (1855).

[‡] Compt. rend., xlvii, (1858).

[‡] Nitrogren in seed and nitrate.

The soils used were ignited, washed, and re-ignited, pumice, or soil. The specially made pots were ignited before use, and cooled over sulphuric acid under cover. The pots, with their plants, were enclosed under a glass shade resting in the groove of a specially made hard-baked glazed stone-ware lute-vessel, mercury being the luting material. Under the shade, through the mercury, passed one tube for the admission of air, another for its exit, and another for the supply of water or solutions to the soil; and there was an outlet at the bottom of the lute-vessel for the escape of the condensed water into a bottle affixed for that purpose, from which it could be removed and returned to the soil at pleasure. A stream of water being allowed to flow into a large stone-ware Wolff's bottle (otherwise empty), air passed from it through two small glass Wolff's bottles containing sulphuric acid, then through a long tube filled with fragments of pumice saturated with sulphuric acid, and lastly through a Wolff's bottle containing a saturated solution of ignited carbonate of soda; and, after being so washed, the air enters the glass shade, from which it passes, by the exit tube, through an eight bulbed apparatus containing sulphuric acid, by which communication with the unwashed external air is prevented. Carbonic acid is supplied as occasion may require, by adding a measured quantity of hydrochloric acid to a bottle containing fragments of marble, the evolved gas being passed through one of the bottles of sulphuric acid, through the long tube, and through the carbonate of soda solution, before entering the shade.

It will be observed that, by the arrangement described, the washed air is forced, not aspirated, through the shade, and the pressure being thus the greater within the vessel, the danger of leakage of unwashed air from without inward is lessened. In 1857, twelve sets of such apparatus were employed; in 1858 a larger number, some with larger lute-vessels, and shades; in 1859 six, and in 1860 also six. The whole were arranged, side by side, in the open air, on stands of brick-work, as described in the papers referred to, and shown in the apparatus exhibited. Drawings of some of the plants grown were also exhibited, and the published results are summarized in Table VII.

Table VII.—*Summary of the Results of Experiments made at Rothamsted, to determine whether Plants assimilate Free Nitrogen.*

			Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
			In Seed, and Manure, if any.	In Plants, Pot and Soil.	Gain or Loss.	
With no *combined Nitrogen supplied beyond that in the seed sown.*						
Gramineæ. ..	1857.	Wheat...	0·0080	0·0072	—0·0008	0·90
		Barley...	0·0056	0·0072	+0·0016	1·11
		Barley...	0·0056	0·0082	+0·0026	1·46
	1858.	Wheat...	0·0078	0·0081	+0·0003	1·04
		Barley...	0·0057	0·0058	+0·0001	1·02
		Barley...	0·0063	0·0056	—0·0007	0·89
	1858. A*	Wheat...	0·0078	0·0078	0·0000	1·00
		Oats.....	0·0064	0·0063	—0·0001	0·98
Leguminosæ.	1857.	Beans ...	0·0796	0·0791	—0·0005	0·99
	1858.	Beans ...	0·0750	0·0757	+0·0007	1·01
		Peas	0·0188	0·0167	—0·0021	0·89
Other Plants.	1858.	Buck Wheat -	0·0200	0·0182	—0·0018	0·91
With *combined Nitrogen supplied beyond that in the seed sown.*						
Gramineæ. ..	1857.	Wheat...	0·0329	0·0383	+0·0054	1·16
		Wheat...	0·0329	0·0331	+0·0002	1·01
		Barley...	0·0326	0·0328	+0·0002	1·01
		Barley...	0·0268	0·0337	+0·0069	1·25
	1858.	Wheat...	0·0548	0·0536	—0·0012	0·98
		Barley...	0·0496	0·0464	—0·0032	0·94
		Oats	0·0312	0·0216	—0·0096	0·69
	1818. A*	Wheat...	0·0268	0·0274	+0·0006	1·02
		Barley...	0·0257	0·0242	—0·0015	0·94
		Oats	0·0260	0·0198	—0·0062	0·76
Leguminosæ.	1858.	Peas	0·0227	0·0211	—0·0016	0·93
		Clover ..	0·0712	0·0665	—0·0047	0·93
	1858. A*	Beans ...	0·0711	0·0655	—0·0056	0·92
Other Plants.	1858.	Buck Wheat -	0·0308	0·0292	—0·0016	0·95

The upper part of the table shows the results obtained in 1857 and 1858 in the experiments in which no combined nitrogen was supplied beyond that contained in the seed sown. The drawings show how extremely restricted was the growth under these conditions, and the figures in the table show that neither with the Gramineæ, the Leguminosæ, nor with buck-wheat, was there in any case a gain of three milligrams of gen indicated. In most cases there was much less gain this, or a slight loss. There was in fact nothing in these ts to lead to the conclusion that either the Gramineæ, the minosæ, or the buckwheat had assimilated free nitrogen.

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* These experiments were conducted in the apparatus of M. G. Ville.

e lower part of the table shows the results obtained in and 1858, in the experiments in which the plants were lied with known quantities of combined nitrogen in the of a solution of ammonium sulphate applied to the soil. gains or losses range a little higher in these experiments, hich larger quantities of nitrogen were involved, but they lways represented by units of milligrams only, and the s are higher than the gains. Further, the gains, such as are, are all in the experiments with the Gramineæ, while is in each case a loss with the Leguminosæ, and with the wheat. On this point it should be stated that the growth far more healthy with the Gramineæ than with the Legu- sæ, which are even in the open fields very susceptible to vicissitudes of heat and moisture, and were found to be emely so when enclosed under glass shades. It might be ted, therefore, that the negative result, with the Legumi- are not so conclusive as those with the Gramineæ. How- this may be, taking the results as they stand, there is ing whatever in them to lead to the conclusion that either raminæ or the Leguminosæ can take up and assimilate ree nitrogen of the atmosphere. We, indeed, do not hesi- to conclude from our own experiments, as Boussingault rom his, that the evidence is strongly against the supposi- that plants can so avail themselves of the free nitrogen of tmosphere.

dependently of the action suggested as possible by M. G. , that is between free nitrogen and nascent or ozonized en within the plant itself, it has been supposed that the nitrogen of the atmosphere may unite with the nascent en, or ozone, as the case may be, evolved by the plant, o yield nitric acid. In our papers above referred to we given reasons for supposing that such actions are not y to take place; but whether they do or do not, it is at rate certain that in our own experiments we have not been to persuade plants to avail themselves of this happy ty of producing their own nitrogenous food. With regard e action supposed possibly to take place externally to the itself, if it were in any material degree operative, we ld expect some, at least, of the resulting combined nitro- to be collected in the aqueous deposits from the atmos- ; but we have seen how inadequate is the amount of ined nitrogen in those deposits to account for the yield of gen, even of the Gramineæ, and still less can it satisfac- explain the yield in the Leguminosæ and other plants.

[To be continued.]

ART. XII.—*On the Orbit of the planet Urda* (167); by C. H. F. PETERS.

THIS planet was discovered as a star of 12th magnitude on August 28th ult., and the observations obtained, after applying corrected star positions, are the following, each being the mean from twelve comparisons by ring-micrometer.

1876.	Ham. Col. m. t.			App. α (167).			App. δ (167).		
	h	m	s	h	m	s	°	′	″
Aug. 28,	14	18	21	21	58	32·22	−11	23	41·2
" 30,	13	35	16	21	57	2·27	−11	33	23·3
Sept. 12,	12	48	43	21	48	16·70	−12	31	14·2
" 15,	12	19	28	21	46	38·63	−12	42	24·8

It seems that the planet has not been seen anywhere else; and the orbit therefore had to be evolved from the foregoing observations alone, however unequally distributed over an interval of only eighteen days. I succeeded by computing first a circular orbit, which served for freeing the observations from aberration and parallax, and then using of the eight data the four longitudes and the two extreme latitudes. The final ellipse arrived at is the following:

Epoch, 1877, Jan. 0·0 Berlin m. t.

$L = 317^\circ\ 43'\ 27{\cdot}4''$.
$\pi = 32^\circ\ 39'\ 22{\cdot}2'' + 50{\cdot}24''\ (t. - 1876)$.
$\Omega = 170^\circ\ 7'\ 25{\cdot}4'' + 49{\cdot}25''\ (t. - 1876)$.
$i = 1^\circ\ 42'\ 14{\cdot}5'' - 0{\cdot}47''\ (t. - 1876)$.
$\varphi = 18^\circ\ 10'\ 30{\cdot}6''$.
$\mu = 614{\cdot}475''$.
$\log a = 0{\cdot}507668$.

Of these elements, three, viz., node, inclination and major axis, bear a remarkable resemblance to those of Gerda (122). Moreover, the element of the excentricity, as it is derived from so short an arc in our orbit, remains necessarily very uncertain. The same is the case, though in less degree, and for the same reason, with the position of the apsides, or the longitude of perihelion. Only the remaining 6th element, therefore, can decide, whether the two planets are identical. Now, for the same epoch we have for Gerda L=168° 46′, and as the correctness of Mr. Stockwell's computations of Gerda are fully confirmed by observations upon this planet made at Berlin in April last, it is proved that Urda is distinct from Gerda.

The fact of two planets moving in the same plane, with the same time of revolution, having also the line of apsides in common (our elements, if correct, show a longitude of perihelion nearly 180° distant from Gerda's), but with a widely different excentricity, is worthy of note. And it is therefore still more desirable, that Urda should not pass unnoticed in its next opposition, which will occur in January, 1878, and when the planet will be of the 12·7 magnitude.

Litchfield Observatory of Hamilton College, Jan. 6, 1877.

ART. XIII.—*Principles of Compensation in Chronometers;* by J. B. JAMES, M.D., Trenton, N. J.

"FOR one to know, is nothing, unless others also may know," is an aphorism of modern progressive science; for it is only from what has been attained that step by step further progress may be made. This it is which impels the writer to offer some considerations on the principles of compensation in chronometers.

It may be assumed as an axiom of general application, that an error should be avoided whenever it is possible, rather than compensated; yet this plain axiom is disregarded in the compensation balance, in two respects.

1st. What is the action of the laminated rim as affected by change of temperature? The end of the arm is commonly regarded as a fixed point, which it is not; for its distance from the center is changed by change of temperature; and whatever weight is here, if its distance from the center is changed, that change must be compensated at the other end of the segment; and therefore this is not the place for mean-time screws; while between these two ends of the segment, there must be a point whose distance from the center undergoes little or no change, and where its weight requires no compensation for change of temperature. This point of uniform distance from the center, when ascertained, should therefore be regarded as the *fixed point;* and if the compensation required were only for the changes in the balance itself, it would be absolutely perfect; for as the one end of the segment recedes from the center, the other approaches it—the one merely taking the place of the other; and this would be in effect true whether the ends were equidistant from the fixed point or not—the longer segment requiring only the less weight. It is the attempt to compensate, in the balance, for changes in the length and elasticity of the spring that creates the necessity for a *secondary* compensation.

This principle of compensation for temperature has been practiced in the pocket chronometer, with marked success, by Henry B. James, of Trenton N. J., for some years. He attaches the outer end of the balance spring to the elastic arm of a laminated convolute, which, at the same time that it compensates, more or less, for changes in the spring, permits a more free movement of the balance; while, parting the rim of a balance having equal thicknesses of brass and steel in its structure, at a distance of one-sixth of its circumference from the arm, he assumes the middle of the longer portions, and the free ends of the shorter, as places where weight requires no compensation, the longer portions carrying on their free ends only a moderate weight for the compensation needed.

2d. The work performed by the balance near its center of motion is a source of error that has been generally neglected. It is a settled principle of dynamics, that "if a body revolving on an axis strike an immovable obstacle at the *center of percussion*, the point of suspension will not be affected by it;" while "if the blow be struck in any other point, a part of its motion will be employed in endeavoring to continue the motion." Thus if we take into the hand at one end a club of uniform thickness, and by a motion from the wrist as a center strike an obstacle at a distance of one-third its length from the other end, the hand feels no effect from the blow; but if it be struck by any other point, the hand will receive a part of the blow,—greater as it is further from the point named. Now the "center" or *line* of percussion of a balance is in or near the rim, and the resistance to its motion, by means of the spring and escapement, is near its center; and the force thus lost, as to the movement of the spring and escapement, is transmitted to the pivots of the balance as useless friction. The errors arising from the relative positions and directions of these forces and that of gravitation, and the changes therein from change of position or latitude, from the density of the air and the space in which the balance moves, varying friction from the oil, lurches on shipboard or jolts in the pocket, and from the different rates of expansion of metals as they affect the friction of the balance or pivots or the working of the escapement—these furnish a problem to ascertain or compensate their average effects, sufficiently complicated to account for the little progress that has been made in perfecting the chronometer. For however small may be their effects on a single movement of the balance, when it is multiplied by fourteen to eighteen thousand for every hour, or three or four hundred thousand in twenty four hours, they become so readily appreciable as to deserve attention and amelioration.

Now if we can remove from the balance pivots this intermittent and useless friction, leaving only its own greatly reduced and uniform amount, unchanged by change of position or temperature, a balance of greater momentum could be substituted, which, in a proportionate degree would lessen the effect of the remaining sources of error, and this, it is believed, can be accomplished by simple and practicable mechanism.

ART. XIV.—*Notes on the Vespertine Strata of Virginia and West Virginia*; by WILLIAM M. FONTAINE.

(Concluded from page 48.)

Vespertine of Augusta and Rockingham Counties.

My principal examinations in this quarter were made at "North River Gap," in the northern corner of Augusta county, in the "Dora Coal Field." In this part of the State the eastern edge of a fractured portion of the Vespertine area seems to have been pressed down against the massive Lower Silurian limestone, along the line of fault which runs on the west side of the "Valley of Virginia." This has resulted in the overturn of the strata westward, and the catching of a narrow synclinal belt of the middle member under the massive sandstones of the lower portion. These, by their resistance to erosion, have preserved from removal the more destructible strata of the coal-bearing rocks, and standing up in huge ribs, form the core of the Great North Mountain, here called locally, "Narrow Back." As might be expected, especially in the mountain itself, the amount of contortion and crushing is immense.

The sandstones are changed to quartzites, with all granular structure obliterated. The shales which contain the coal, from their more yielding nature, have suffered most. Where they are exhibited in the western face of the mountain, they are thrust through the coal seams, and wrapped in the most complicated contortions. In places they seem to have been drenched with water holding silica in solution. They sometimes contain lumps and strings of quartz, deposited by such waters. Yet with all this, they are true shales, being rendered only more compact and harder. This is another striking example of the difference in the amount of metamorphic action, produced in sandstones and shales, when subjected to the same influences, and of the insufficiency of mechanical disturbance to produce more than the first stages of metamorphism.

The convoluted and disturbed strata of the mountain dip southeast at a high angle. After passing it to the west, the dip flattens rapidly, and while the rocks of the mountain are inverted, we now find them in their normal position. We may compare the structure of the belt to a fish-hook, with its shank turned westward, the bend representing the mountain. The material of the hook would represent the sandstones of the lower Vespertine, while we may conceive the middle member with its coals as filling the curve, and resting upon the shank. It will thus be seen that the number of coal beds will be doubled by overlap in the west face of the mountain. The strata have suffered much from erosion, and show only the lower and middle members. It is however by no means certain that the upper member of red shales was ever present. The increase in the coarseness and amount of the sandstones underlying the coal strata seems rather to indicate its former absence. No limestone appears here.

I did not make a complete section at this point of the strata supposed to represent the Catskill. Enough however was seen to show that red shales appear here at the same horizon as at Lewis Tunnel, but the amount is not so great, and they are now changed to red argillaceous flags. The upper members here are somewhat massive liver-colored sandstones, which graduate upward into the white sandstones of the lower Vespertine. The Catskill? strata seem to be considerably thicker in this region than at Lewis Tunnel.

The sandstones of the lower member of the Vespertine cannot be separated by any distinct dividing line from the above mentioned rocks. But, assuming for their base the strata which do not show a predominance of the red color, they show a thickness of about 400 feet. All are highly siliceous, and lie in pretty massive beds. No dividing line can be drawn in this mass of rock, but a gradual change may be traced. At the base it is brownish gray, then gray, and finally white, passing near the top into gray flags. The white portion is about 200 feet thick, being mainly a massive quartzite, but showing in the lower portion some conglomerate bands. Over the above mentioned rocks are about 40 feet of gray flags, in the top of which is the lowest coal bed. This stratum may be taken as the lower portion of the middle member. The following is the section from the lowest coal ascending to the highest:

1. Black siliceous shales, (floor).
2. Coal, 18 inches.
3. Argillaceous sandstone, 4 feet.
4. Black siliceous shale, 6 inches.
5. Sandstone, 8 inches.
6. Black siliceous shale, 4 feet.
7. Sandstone, 1 foot.
8. Black shale, 5 feet.
9. Coal, 2–2½ feet.
10. Black siliceous shale, 12 ft.

No. 2 is very impure, and where it is best has several partings of shale. It is very variable in the amount of coal, and often runs almost entirely into shale. No. 6 has some thin strings of coal, as is the case with No. 8. No. 9 is the most constant bed, and has the largest amount of clear coal. In the top of No. 10 a few thin strings of coal sometimes occur.

The remaining rocks above No. 10 are gray and bluish-gray sandy shales, showing in some places abundant plant impressions. The exposures are too poor to allow any approximation to their thickness.

The coal here is a true anthracite, of pretty good quality. Attempts have been made, from time to time, to work it, but without success. The large amount of carbon in some of the shale immediately associated with the coal, its highly glazed aspect (from friction), and the intimate manner in which it is mixed with the true coal, have led to an exaggerated estimate of the thickness of the beds. This mistake was aided by the imperfect manner in which the coal was exposed in the outcrops. From these causes I was myself led, some two years ago, on my first visit to the place, to think the amount of coal greater than it has proved to be. Of late the somewhat extensive exploration made in this field by the Royal Land Co., of Virginia, has demonstrated that the amount of coal is too small, and its crushing too great, to render it of commercial value.

The Vespertine strata in Montgomery County.

I have not had the good fortune to procure a copy of Prof. Lesley's "Description of the South Virginian Coal Region of Montgomery and Wythe counties," published in vol. ix, Proc. Am. Phil. Soc. No doubt this would have aided me greatly in my study of the Vespertine of Montgomery, to which my investigations were confined.

The Vespertine strata in Montgomery county occupy two distinct areas, which require separate descriptions. The most important of these is the narrow tract lying on the northern side of the great fault, which passes just south of Brush Mountain. This is but the continuation, to the south, of the belt just described in Augusta county.

The smaller area lies about two miles south of Brush Mountain, from which it is separated by a narrow belt of Lower Silurian limestone, and about two and a half miles northwest of Christiansburg. This small area, so far as I know, has never received the notice that it deserves. Prof. Rogers simply speaks of it as an outlier of Vespertine, similar in character to that of Brush Mountain. But little was known of it then, and even up to the late war, when its coals were examined and worked to some extent. Since then the good quality and thickness of the beds, as well as the ease with which they may be worked, have led to their farther development.

The structure of this field, which bears the name of Price's Mountain, is one of the most curious products of the force which has produced the numerous faults in this region. It is a belt, with an anticlinal structure, about seven miles long, and 2½ wide, running nearly east and west, (more accurately, 10° N. of E.).

The maps of Virginia show a mountain chain, under the name Alleghany, running by Christiansburg in a northerly direction, to meet Brush Mountain. This is merely a watershed, and does not appear above the surrounding country as mountain. The eastern end of the Vespertine belt in question is found in this watershed. From that point, where the strata stand at the general level of the country, they run nearly in a westerly direction toward New River, and pass about 2½ miles northwest of Christiansburg. The strata of the eastern end are the red marlites of the upper member. In passing westward they begin to rise into an anticlinal elevation, which soon attains the height of about 300 feet, which height is maintained for about 3½ miles, showing a continuous ridge. This portion bears the name of Price's Mountain. Farther west, toward the river, the ridge is broken up into hills, and then finally disappears before the stream is reached. I am informed that no trace of the strata is to be found west of New River, where the rock is all limestone.

As the ridge rises in passing west, the coal-bearing strata of the middle member begin to appear through the red marlites, and where it is highest, the upper part of the lower member appears in the crest. In this portion the coals are worked. Here we find the red marlites forming an outer band on each side of the ridge, and cut off abruptly north and south by the Lower Silurian limestone, which also sweeps around the eastern end. The coal strata occupy the foot, and reach some distance up the slope, on each side. The field seems to be a prism of Vespertine strata, engulfed by a double fault in the limestone, with its eastern end tipped lower than the middle and western portions. The dip of course is nearly north and south, away from the crest, and toward the limestone.

The amount of contortion and rubbing exhibited by the strata is surprisingly small. The roof and floor of the openings made are as uniform and smooth as those of our upper coals of the West. As a consequence, the coal is worked with ease, and unlike that of Brush Mountain, two miles off, shows but little rubbing, and may be taken out in blocks of any size. There are two beds here as in Brush Mountain, being evidently the same. The amount of slate partings is however smaller in Price's Mountain, and the coal thicker.

As the middle member containing the coal beds is evidently similar to that exposed in Brush Mountain, while the exposure here is not so good, the section of it taken in that mountain will suffice for both localities. The same may be said of the lower member. The upper red beds however are much better displayed here, and the section of them, taken from the northern foot of Price's Mountain northward to the limestone, will be given as a representative one. We find here these rocks well exposed, with a steady northward dip, until they are suddenly cut off by the limestone.

The dip on the north side is somewhat steeper than on the south side, being in the former case 30° N.N.W., and in the latter, 26° S.S E. The coal of the upper bed on the north side is somewhat thicker than that on the south side. The lower bed is essentially the same on both sides. The lower bed everywhere averages about two feet. It is enclosed in gray flags, and separated from the upper by about forty feet of the same kind of rock.

An average section for the upper bed on both sides, is as follows, commencing at the top:

1. Black slate, (roof).
2. Coal, 12 inches.
3. Slate, 12 inches.
4. Coal, 2½ feet.
5. Slate, 7 inches.
6. Coal, 10 inches.
7. Slate, (floor).

No. 4 sometimes runs up to three feet, and the other layers of coal show occasionally an increase of several inches in thickness.

The following section, omitting details, will give the character of the red upper member, commencing below:

1. Interstratification of brown sandstone, and red shale, 50 feet.
2. Red and mottled marlites, with some brown sandstone, 440 ft.
3. Thinly fissile, red shales, " " " " 600 feet.

A regular change may be traced in the character of these sediments. No. 1 and No. 2, in the lower portion, have a larger proportion of sandstone. But in the greater portion of No. 2, especially the middle and upper parts, and in all of No. 3, the sandstone appears only in occasional beds. The lower portion of No. 2 is often mottled with spots and streaks of gray and green. The indications are that the strata were deposited during a steadily progressing subsidence.

This thickness of 1090 feet of red shales and marlites is suddenly cut off on the northern side, by the Lower Silurian limestone, which throughout this region has a southeast dip, and shows a considerable amount of alteration. No remnant of the Lower Carboniferous, or Lewisburg limestone, is seen here, and if it were ever present, it has been removed by erosion. It is clear that this mass of red strata was deposited prior to this limestone, if it were ever formed here. In any case we would have a great development of the upper member, as compared with the same near Lewis Tunnel, and this agrees well with the development of the two underlying members in this region.

I am inclined, however, to think that all of these beds were not deposited before the limestone. The increasing fineness of the upper portion No. 3, and other indications that this part was formed in comparatively deep and quiet waters, make it quite probable that No. 3 is the representative here of the limestone. So far as I know the limestone has been seen by no one so far to the east. The sudden cutting off of the Lower Carboniferous limestone by faults in its most easterly known exposures, renders it difficult to draw any conclusions from a change of thickness.

Brush Mountain lies to the north of Price's Mountain, and is separated from it by a belt of Lower Silurian limestone about 1¼ miles wide. Its structure is very simple. The northern foot is composed mainly of Chemung strata, while the central mass is formed of the lower member of the Vespertine, which extends some distance down the southern slope. A portion of the southern face and foot of the mountain is composed of the middle or coal-bearing member, while a band of red rocks belonging to the upper member forms the foot-hills next to the limestone belt. By the great fault, mentioned before as running on the western side of the valley of Virginia, this mass of strata has been brought down so as to abut against the Lower Silurian limestone. Though there has been no overturn of the strata, yet some slight shifting of the beds has been produced, causing a considerable amount of rubbing and crushing. This has made itself felt, especially in the coal, which in consequence is much more fractured and rubbed than that of Price's Mountain, yet by no means so much so as that of Augusta and Rockingham counties. Poverty Creek, after flowing for some distance along the north side, cuts directly through this mountain, and gives a good section of all the strata of the Vespertine. The dip is 30° S.S.E. toward the fault. My section was taken along this creek, commencing on the north side in the Chemung beds, and proceeding south to the upper member of the Vespertine.

The Chemung beds show the same character here as at Lewis Tunnel. The same alternations of flaggy sandstone and shales, with thin layers containing numerous impressions of shells, are found. These beds are to be seen within a space of 400 feet, under the lowest of the Vespertine strata. This interval was too much concealed to enable me to determine whether it is occupied by Chemung beds, or strata which may be the equivalents of the Catskill. If the latter are present here, they must be less than 400 feet thick. I am inclined to think that they are entirely absent, having been replaced by the greatly thickened lower beds of the Vespertine. The following is the section of the latter in ascending order.

Lower member of the Vespertine.

1. Massive white conglomerate and sandstone, 80 feet.
2. Massive white sandstone, with layers of conglomerate, 150 feet.
3. Thin-bedded white siliceous sandstones, 100 feet.
4. White and yellowish flags, marked with red spots and streaks, 300 feet.
5. Siliceous gray sandstones and flags, 300 feet.

Total for the lower member, 930 feet.

No. 1 is a conglomerate of remarkable coarseness, and contains only subordinate bands of coarse white sandstone. Most of the pebbles are from a half an inch to an inch in size, but many are two inches in diameter, and flat. The quartzose matter is all pure white, and plainly derived from the Potsdam and underlying quartzites, as may be easily seen from the nature of the larger pebbles. The smaller pebbles are rounded. The great coarseness, pure siliceous character, and white color of this stratum, contrast in the most striking manner with the underlying Chemung beds, and point to a radical change in the conditions of deposition.

No. 2 is a highly siliceous, white sandstone, with subordinate bands of smaller pebbles. A gradual change from a highly siliceous character to a more argillaceous one, may be traced as we ascend in the series. No. 4 is marked with streaks and spots of red, and begins to show some argillaceous matter, especially toward the top, while in No. 5 a large amount of this material is present. This latter is heavy bedded toward the bottom, and more flaggy toward the top.

Middle member of the Vespertine.

1. Argillaceous gray sandstones, 200 feet.
2. Coal. Upper bed, thickness not exposed.
3. Massive and flaggy gray sandstones, interstratified, 120 feet.
4. Bluish, argillaceous gray flags, 350 feet.

Total for the middle member, 670 feet.

The lower coal-bed was not seen in this section. No. 3 is rather more massive and siliceous here than in Price's Mountain. In No 4, occasional beds 10 to 15 feet thick occur, more massive and siliceous than the great body of the mass. Next above No. 4 come the red beds of the upper member.

The coals of Brush Mountain lie in two beds, identical with those of Price's Mountain, but, as stated before, the amount of slate partings is greater, as is the disturbance to which they have been subjected. Still the upper bed here is also worked to a considerable extent. The lower bed has a sandstone floor and roof. It is about three feet thick, with a slate parting in the middle, from five to ten inches thick. This bed was formerly worked on a small scale, but is now entirely neglected. The upper bed is separated from this by from thirty-five to forty feet of gray flags. About half way between the two, at some of the openings, a small seam twelve inches thick, is reported to exist. The following is the section of the upper bed:

No. 1. Bottom slate.
" 2. Coal, 8 inches.
" 3. Slate, 3 inches.
No. 4. Coal, 6 inches.
" 5. Slate, 1 inch.
" 6. Coal, 6 inches.

No. 7. Slate, 10 inches.
" 8. Mining dirt, 6 inches.
" 9. Main coal, 20–30 inches.
" 10. Slate, 8 inches.
No. 11. Slaty coal, 6 inches.
" 12. Mining dirt, 6 inches.
" 13. Coal and slate, 20 inches.
" 14. Coal, 10 inches.

No. 2 is quite soft, and a good material for blacksmiths. The "bearing in" is done in Nos. 8 and 12. These are composed of crushed coal and slate. All the material above and below them is neglected. The roof above No. 14 is a coarse sandstone with some pebbles. In some localities two small seams occur above this bed, within the space of forty-five feet. These small seams may occur in Price's Mountain, but were not seen.

The coal is all semi-bituminous, some of it approaching an anthracite. The coal of the lower bed is harder than that of the upper. In Price's Mountain the coal of the main portion of the upper bed is a handsome, firm material, with a dull lustre, much resembling the natural coke of the Richmond coal field. It seems here to be remarkably free from sulphur. The coal of Brush Mountain is usually glazed by friction, and seems to have more sulphur. An analysis by Prof. Rogers makes these coals to contain: 14 p. c. bituminous matter, 80 p. c. carbon, and 6 p. c. of ash. The ash is very fine, and of a white color. The coal is said to be excellent for grates and stoves.

It will be seen from the above account that there has been a very marked thickening of the Vespertine as we proceed from north to south through the state, accompanied by an increase in the amount of coal contained in it. This increase seems to be largely at the expense of the supposed Catskill beds. It is in conformity with a law of increase which holds good for all the strata from the Devonian to, and including, the Lower Barren Measures of the Upper Coals.

Plants.

I have, whenever opportunity offered, made a collection of the plant impressions, but owing to their peculiar mode of distribution, and the small amount of excavation made in these strata, I have, as yet, not been able to procure a collection large enough to be offered as representative of the series. Hence I will not attempt to give here anything but a few general statements, which may be greatly modified by farther discoveries.

So far as my observations go, the plants of this series of strata occur at any given locality, with but few species, while these are marked by the great number of individuals which they exhibit. These species are widely distributed, and perfectly characteristic of the series, at least as compared with the flora of the beds above the Conglomerate. The most important and characteristic plants are the following:

1. *Lepidodendron.* The forms of Lepidodendron are the most abundant and widely distributed. They are all characterized by small leaf-scars.

2. *Palæopteris.* This shows two types. By far the most abundant and widely distributed is the form with narrow elliptical leaflets, like *P. Jacksoni.* We find much less abundantly, a second type with broad flabellate leaflets, like *Palæopteris obtusa.*

3. *Triphyllopteris.* To this, I consider Mr. Meek's *Cyclopteris Virginiana*, and *C. Lesueuriana*, as belonging. The latter plant, with possibly a similar species, is widely distributed and very abundant in some localities, forming all the impressions to be found.

I have nowhere seen any impressions of Sigillaria, Calamites, Sphenopteris, and others of the most common plants in the productive coal-measures. In only one case have I seen a specimen of Neuropteris, and this was a remarkably fine one, of *N. flexuosa*, found at Lewis Tunnel. This place has yielded a much greater variety of plants than any other locality visited by me. Of course this negative evidence, in the absence of extended exploration, cannot be taken as excluding the former presence of these plants in the Vespertine. Still it is peculiar that with the many hundreds of specimens seen at widely distant localities, none of those plants noted above as not seen, should have been met with.

ART. XV.—*Contributions from the Sheffield Laboratory of Yale College.* No. XLI.—*On the Chemical composition of the flesh of Hippoglossus Americanus;* by R. H. CHITTENDEN.

THE *Hippoglossus Americanus* of Gill, or halibut as the fish is commonly called, is found in the waters of the Atlantic ocean from Newfoundland to Cape Hatteras. The halibut belongs to the class of white-blooded fish, of which the *Merlangus vulgaris*, or whiting, is a typical representative. The flesh of the halibut is of a fine white color, quite delicate and tender, and is highly valued for food, especially in certain portions of the United States.

A fresh sample obtained at the market yielded by analysis

	No. 1.	No. 2.
Water	82·85	82·90
Solids	17·15	17·10
Ash	1·08	1·08
Fat	1·21	1·32
Nitrogen	2·02	2·00
Phosphoric acid (P_2O_5)	·37	

The fresh flesh of the whiting yielded Payen*—

Water	82·95
Solids	17·05
Ash	1·08
Fat	·38
Nitrogen	2·41

According to Pavy the flesh of the whiting which is eaten so extensively in England, is tender, easily digested, and highly nutritious. A comparison of these two analyses shows but very little difference in the chemical composition of the flesh of the halibut and whiting.

The flesh of the halibut dried at 100° C. yielded by analysis:

	No. 1.	No. 2.
Carbon	50·30	50·46
Hydrogen	7·36	7·51
Nitrogen	11·70	11·66
Ash	6·32	6·39
Oxygen	24·32	23·98
	100·00	100·00
Fat	7·08	7·15

The ash of the flesh gave by analysis:

Silica	·32
Chlorine	11·11
Carbonic acid	1·13
Sulphuric acid	1·30
Phosphoric acid	34·36
Iron	·19
Lime	·15
Magnesia	2·43
Potash	37·07
Soda	12·22
Lithia	trace
	100·28

The ash for the analysis was obtained by carbonizing a large quantity of the flesh, then leaching this carbonized mass with hot water to remove chlorides. The residue left undissolved by the water was then ignited at a higher temperature until burned white. The aqueous solution of the chlorides was then poured over the insoluble residue and the whole heated until the water was completely driven off. This residue was ignited gently and yielded a perfectly white ash.

By a backward glance at these analyses we see that the food value of the flesh of the halibut is not of a low order, but compares favorably with the flesh of other fish of the same class.

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* Compt. Rend., xxxix, 318.

ART. XVI.—*Notice of Darwin on the Effects of Cross- and Self-Fertilization in the Vegetable Kingdom*;* by ASA GRAY.

MR. DARWIN, in the title of his new work, refers only incidentally to adaptations for cross-fertilization,—a subject which has given origin to a copious literature since he opened it anew in his book on the Fertilization of Orchids, in 1862. A new edition of this latter book is on the eve of publication in England, and we believe that this author's scattered papers on cross-fertilization, as secured by various contrivances, are about to be collected, revised, and issued in a book form. In the volume now before us, Mr. Darwin deals with the effects of cross- and self-fertilization, recounts at length the experiments he has devised and carried on, collects and criticises the results, glances at the means of fertilization, and the habits of insects in relation to it, and ends with some theoretical considerations or inferences suggested by or deduced from the facts which have been brought to light.

If writing for the popular press, we should be bound to say that this book is not light reading. Three-fourths of its pages and of the chapters are devoted to the details of the experiments and the sifting and various presentation of the results; and the remainder, although abounding in curious facts and acute suggestions, is yet of a solid character. The bearings of various points upon what is called "Darwinism" are merely touched or suggested, here and there, in a manner more likely to engage the attention of the thoughtful scientific than of the general reader.

That cross-fertilization is largely but not exclusively aimed at in the vegetable kingdom, is abundantly evident. As Mr. Darwin declares, "it is as unmistakably plain that innumerable flowers are adapted for cross-fertilization, as that the teeth and talons of a carnivorous animal are adapted for catching prey, or that the plumes, wings, and hooks of a seed are adapted for its dissemination." That the crossing is beneficial, and consequently the want of it injurious, is a teleological inference from the prevalence of the arrangements which promote or secure it,—an inference the value of which increases with the number, the variety, and the effectiveness of the arrangements for which no other explanation is forthcoming. That the good consisted in a re-invigoration of progeny, or the evil of close-breeding in a deterioration of vigor, was the suggestion first made (so far as we know), or first made prominent, by Knight, from whom Darwin adopted it. However it be as to animals, there was until now no clear and direct evidence that cross-fertilization in the vegetable kingdom did re-invigorate. Indeed, the contrary might be inferred from the long and seemingly indefinite perpetuation of bud-propagating varieties, which have no fertilization at all. But the inference from this is not as cogent as would at first appear. For, although bud-propagation is, we think, to be considered as the extreme of close-breeding, yet in it the amount of material contributed by parent to offspring is usually vastly more than in sexual reproduction: and, accordingly, the diminution to an injurious degree of any inherited quality or essence might be correspondingly remote. Yet, as sexual reproduction may be and often must be much closer in plants than it can be in most animals, the ill effects of self-fertilization, or the good of cross-fertilization, might the sooner be noticeable. Mr. Darwin arranged a course of experiments to test this question, prosecuted it as to some species for eleven years; and the main object of this volume is to set forth the results.

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* The Effects of Cross- and Self-Fertilization in the Vegetable Kingdom; by CHARLES DARWIN, M.A., F.R.S., etc. London: Murray. (New York: D. Appleton & Co.) 12mo, pp. 482. 1876.

Ipomœa purpurea, the common Morning Glory of our gardens, was the leading subject. The flowers of this species self-fertilize, but must also be habitually cross-fertilized, as they are visited freely by humble-bees and other insects. Ten flowers of a plant in a greenhouse were fertilized with their own pollen; ten others were crossed with pollen from a different plant. The seeds from both were gathered, allowed to germinate on damp sand, and as often as pairs germinated at the same time the two were planted on opposite sides of the same pot, the soil in which was well mixed, so as to be uniform in composition. "The plants on the two sides were always watered at the same time and as equally as possible, and even if this had not been done the water would have spread almost equally to both sides, as the pots were not large. The crossed and self-fertilized plants were separated by a superficial partition, which was always kept directed towards the chief source of the light, so that the plants on both sides were equally illuminated." Five pairs were thus planted in two pots, and all the remaining seeds, whether or not in a state of germination, were planted on the opposite sides of a third pot, so that the plants were crowded and exposed to a very severe competition. Rods of equal diameter were given to all the plants to twine up, and as soon as one of each pair had reached the summit, both were measured. But a single rod was furnished to each side of the crowded pot, and only the tallest plant on each side was measured. This was followed up, for ten generations; the close fertilization being always self-fertilization, i. e., by pollen to stigma of the same flower; the crossing, between individuals in successive generations of this same stock, except in special instances, when an extraneous stock was used as one parent,—to eminent advantage, as will be seen.

The difference in vigor between the cross-bred and the close-bred progeny, as measured by early growth, was well marked throughout. In the mean of the ten generations it was as 100 to 77. In the tenth generation it was 100 to 54, that is, five cross-bred plants grew to the average height of 93·7 inches while the close-bred were reaching the average of 50·4 inches. This was a notably greater difference than in any previous generation. But this was probably accidental or anomalous; for it was not led up to by successive steps. Indeed, the difference in the first generation was a trifle greater than the average of all ten, being as 100 to 76. The second generation was as 100 to 79; the third as 100 to 68; the fourth as 100 to 86; the fifth as 100 to 75; the sixth as 100 to 72; the seventh as 100 to 81; the eighth as 100 to 85; the ninth as 100 to 79; the tenth, as already stated, 100 to 54. The general result is made striking in the following illustration.

"If all the men in a country were on an average six feet high, and there were some families which had been long and closely inter-bred, these would be almost dwarfs, their average height during ten generations being only four feet eight and one-quarter inches." (p. 53.)

It is remarkable that the difference between the close-bred and the cross-bred individuals should have been as great as it was in the first generation; and, this being the case, it might have been expected that the difference would have gone on increasing in the succeeding generations. If self-fertilization is injurious, the ill effects would be expected to be cumulative. "But," instead of this, "the difference between the two sets of plants in the seventh, eighth, and ninth generations taken together is less than in the first and second generations together." Upon this Mr. Darwin remarks: "When, however, we remember that the self-fertilized and crossed plants are all descended from the same mother plant, that many of the crossed plants in each generation were related, often closely related, and that all were exposed to the same conditions, which, as we shall hereafter find, is a very important circumstance, it is not at all surprising that the difference between them should have somewhat decreased in the later generations." (p. 56.)

Further light was thrown upon these points by two kinds of subsidiary experiments. In one case, the cross was made between two flowers of the same plant of *Ipomœa*, while other flowers were self-fertilized as before. On raising seedlings from the two lots, it was found that such crossing gave no superiority: indeed, the offspring of the self-fertilized flowers appeared to be rather more vigorous than the close-crossed. And other experiments led to the same conclusion, namely, that there was no particular benefit from cross-fertilization on the same plant. In the other case, the cross was made not only between the flowers of distinct plants, but between those from different sources, and which had presumably grown under somewhat different conditions. For instance, several flowers of the ninth generation of crossed plants of *Ipomœa* were crossed with pollen taken from the same variety, but from a distant garden. The resulting seedlings showed the benefit of the fresh stock remarkably, being as much superior in vigor to those of the tenth inter-crossed generation as the latter were to the self-fertilized plants of the corresponding generation. In height they were as 100 to 78, over the ordinary inter-crossed; and in fertility, as 100 to 51. Indeed, Mr. Darwin's main conclusion from all his observations is, "that the mere act of crossing by itself does no good. The good depends on the individuals which are crossed differing slightly in constitution, owing to their progenitors having been subjected during several generations to slightly different conditions, or to what we call in our ignorance spontaneous variation."

The greater constitutional vigor of the crossed plants of *Ipomœa* was manifested in other ways than their rate or amount of growth; they better endured exposure to a low temperature or sudden changes of temperature; they blossomed earlier; and they were more fertile. The difference in fertility varied greatly in degree (the extremes in different experiments and in different generations being 100 to 99 and 100 to 26), but was always sustained. Also, "the impaired fertility of the self-fertilized plants was shown in another way, namely, by their anthers being smaller than those in the flowers on the crossed plants. This was first observed in the seventh generation, but may have occurred earlier. . . . The quantity of pollen contained in one of the self-fertilized was, as far as could be judged by the eye, about half of that contained in one from a crossed plant. The impaired fertility of the self-fertilized plants of the eighth generation was also shown in another manner, which may often be observed in hybrids—namely, by the first-formed flowers being sterile."

Similar experiments were made, but not carried to the same extent, upon fifty-seven other species of plants, belonging to fifty-two genera, and to thirty great natural families, the species being natives of various parts of the world. The results—the details and discussion of which occupy the bulk of this volume—vary greatly, some plants making a better, and others a less good showing for the advantage of cross-fertilizing, and this advantage manifesting itself in different ways, some in vigor or amount of growth, some in hardiness, most in fertility; but with twelve cases in which the crossed plants show no marked advantage over the self-fertilized. There were, however, fifty-seven cases in which the crossed exceeded the self-fertilized by at least five per cent, generally by much more.

Increase of vigor, as evinced in growth, appears generally to be accompanied by increased fertility; but sometimes the good of crossing was manifested only in productiveness, i. e., in a larger amount of seed. This proved to be the case in *Eschscholtzia*, in which—strange to say—self-fertilized plants of several generations were superior in size and weight to inter-crossed plants, even when the crossing was between flowers derived on one side from American, on the other from English seed, from which, upon Mr. Darwin's view, the maximum benefit should be gained. This instance, however, stands alone. Yet it is approached by several others, in a manner which might have negatived the general conclusions of the research, if they had been hastily gathered from a small number of trials.

For example, in the sixth self-fertilized generation of *Ipomœa purpurea*, one of these plants took the lead of its competitor, kept it almost to the end, and was ultimately overtopped only by half an inch on a total height of several feet. To ascertain whether this exceptionally vigorous plant would transmit its power to its seedlings, several of its flowers were fertilized with their own pollen, and the seedlings thus raised were put into competition with ordinary self-fertilized and with inter-crossed plants of the corresponding generation. The six children of Hero (the name by which this individual was designated), beat the ordinary self fertilized competitors at the rate of 100 to 84, and the inter-crossed competitors at the rate of 100 to 95; and in the next generation the self-fertilized grand-children beat those from a cross between two of the children at the rate of 100 to 94. In the next generation the seedlings were raised in winter in a hot-house, became unhealthy, and the experiment terminated without marked result. Moreover the remarkable vigor of growth in Hero and its progeny was attended by somewhat increased fertility. Here, then, an idiosyncracy arose, from some utterly unknown cause,—a spontaneous variation of constitution, which was transmitted to posterity, and which gave all the benefit of cross-fertilization, and somewhat more, both as to vigor and fertility. A similar idiosyncracy made its appearance in the third generation of seedlings of *Mimulus luteus.*

Discordant or anomalous facts like these seem confusing, even though too few to affect seriously the grand result of the numerous experiments; but upon Darwinian principles, in which adaptations are ultimate results, they are to be expected, as a consequence of the general and apparently vague proclivity to vary.

In Foxglove,—the flowers of which are naturally self-sterile or nearly so, and in which crossing gave a marked advantage over self-fertilizing, both as to growth and productiveness,—a decided, though small advantage, appeared to come from the crossing of flowers on the same plant.

In *Origanum vulgare*, crosses were made between different plants of a large clump, long cultivated in a kitchen-garden, which had evidently spread from a single root by stolons, and which had become in a good degree sterile, as is usual under such conditions. The crossing caused rather more seed to form; but the seedlings from the crossed did not surpass in growth those of the self-fertilized; "a cross of this kind did no more good than crossing two flowers on the same plant of *Ipomœa* or *Mimulus*. Turned into the open ground, and both self- and cross-fertilized the following summer, and equal pairs of the resulting seeds planted on opposite sides of two very large pots, the crossed plants from seed showed a clear superiority over their self-fertilized brethren, at the rate of 100 to 86. But this excess of height by no means gives a fair idea of the vast superiority in vigor of the crossed over the self-fertilized plants. The crossed flowered first and produced thirty flower-stems, while the self-fertilized produced only fifteen, or half the number. The pots were then bedded out, and the roots probably came out of the holes at the bottom, and thus aided their growth. Early in the following summer, the superiority of the crossed plants, owing to their increase by stolons, over the self-fertilized plants, was truly wonderful. . . . Both the crossed and the self-fertilized plants being left freely exposed to the visits of bees, manifestly produced much more seed than their grandparents,—the plants of original clumps still growing close by in the same garden, and equally left to the action of bees."

These few cases must here suffice, and they give a fair general idea of the main results reached,—somewhat qualified, however, by certain instances in which little or no benefit was observed. Let it be remarked that while most of the cases show decided and unequivocal good from the crossing, none of them unequivocally tell to the contrary, as the advantage appears sometimes in one direction, sometimes in another. "Thus, the crossed and self-fertilized plants of *Ipomœa*, *Papaver*, *Reseda odorata*, and *Limnanthes* were almost equally fertile, yet the former exceeded considerably in height the self-fertilized plants. On the other hand the crossed and self-fertilized plants of *Mimulus* and *Primula* differed to an extreme degree in fertility, but by no means to a corresponding degree in height or vigor."

We must wholly omit — among many other things — the interesting account of self-sterile plants, meaning here not those in which the pollen does not reach the stigma unaided, but those in which it is impotent, or nearly so, when applied, although efficient upon the stigma of another individual. *Verbascum*, *Passiflora*, *Corydalis*, and many Orchids afford instances of this sort. In these the advantage of cross-fertilization rises to a necessity. A noteworthy fact respecting them (of which Mr. Darwin makes much) is, that such self-sterility, or the reverse, is influenced by slight changes in the conditions, such as difference in temperature, grafting on another stock, and the like. In South Brazil, Fritz Müller found that for six generations all his plants of *Eschscholtzia Californica* were completely sterile, unless supplied with pollen from a distinct plant, when they were completely fertile. This was not the case in English plants, which, when covered by a net, set a considerable number of capsules, the seeds of which, by weight, were as 71 to 100 of those on plants intercrossed by bees. These Brazilian seeds, sent to England, yielded plants with moderately self-fertile flowers, and this limited self-fertility was increased in two generations of English growth. Conversely, seeds from English plants grown in Brazil were more self-fertile than those reared in Brazil for several generations; yet "one which did not flower the first year, and was thus exposed for two seasons to the climate of Brazil, proved quite self-sterile, like a Brazilian plant, showing how quickly the climate had acted on its sexual constitution." Having observed that certain individuals of Mignonette were self-sterile, Mr. Darwin secured several such plants under separate nets, and by inter-crossing these for a few generations, obtained plants which inherited this peculiarity, so that "without doubt a self-sterile race of Mignonette could easily have been established."

Nine of the twelve chapters are devoted strictly to the effects of cross and self-fertilization. The tenth considers the "means of fertilization." Cross-fertilization is favored or ensured by: 1, the separation of the sexes; 2, the maturity of the male and female sexual elements at different periods; 3, dimorphism or even trimorphism; 4, various mechanical contrivances; 5, the more or less complete inefficiency of a flower's own pollen on its stigma, and the prepotency of pollen from any other individual over that from the same plant. We understand that Mr. Darwin is just now occupied in revising and extending his various papers upon these topics, with a view to their publication in a volume. Here he gives a list of plants which, when insects are excluded, are either quite sterile or produce less than half the number of seeds yielded by unprotected plants. This is followed by a list of plants which, when protected from insects, are either quite fertile or yield more than half the number of seeds produced by unprotected plants.

"Each of these lists contains by a mere accident the same number of genera, viz., forty-nine. The genera in the first list include sixty-five species, and those in the second sixty species; the Orchideæ in both being excluded. If the genera in this latter order, as well as in the Asclepiadeæ and Apocynaceæ, had been included, the number of species which are sterile if insects are excluded would have been greatly increased; but the lists are confined to species which were actually experimented on. The results can be considered as only approximately accurate, for fertility is so variable a character, that each species ought to have been tried many times. The above number of species, namely, 125, is as nothing to the hosts of living plants; but the mere fact of more than half of them being sterile within the specified degree, when insects are excluded, is a striking one; for whenever pollen has to be carried from the anthers to the stigma in order to ensure full fertility, there is at least a good chance of cross-fertilization. I do not, however, believe that if all known plants were tried in the same manner, half would be found to be sterile within the specified limits; for many flowers were selected for experiment which presented some remarkable structure; and such flowers often require insect-aid." (p. 370.)

It is worth noticing that *Trifolium repens* and *T. pratense* (the common white and red clovers) have a place in the first list; *T. arvense* and *T. procumbens* in the second. Darwin refers to Mr. Miner's statement that "in the United States, hive-bees never suck the red clover," and says it is the same in England, except from the outside through holes bitten by humble-bees; yet that H. Müller has seen them visiting this plant in Germany, for the sake both of pollen and nectar, which latter they obtained by breaking apart the petals. Darwin has not qualified his statement, long ago made, of the complete sterility of red clover protected from insects; but Mr. Meehan asserts that protected plants are fertile in this country, without, however, giving details or the rate of fertility. In *T. arvense*, "the excessively small flowers are incessantly visited by hive and humble-bees; when insects were excluded the flower-heads seem to produce as many and as fine seeds as the exposed heads."

As to cross-fertilization, "the most important of all the means by which pollen is carried from the anthers to the stigma of the same flower, or from flower to flower, are insects, belonging to the orders of Hymenoptera, Lepidoptera, and Diptera; and in some parts of the world, birds." In a note the author cites all the cases known to him of birds fertilizing flowers. These are chiefly humming-birds. "In North America they are said to frequent the flowers of *Impatiens*" (for which Gould, Trochilidæ, is referred to as authority, and a reference is given to the Gardeners' Chronicle, which we find relates to something else in South

America); and this is all concerning the United States. Can it be that there are no references in print to the most familiar fact that our humming-bird is very fond of sucking the blossoms of Trumpet Creeper (*Tecoma radicans*) and of Honeysuckles? Both these are, in size and arrangement of parts, well adapted to be thus cross-fertilized.

Flowers are rendered conspicuous to birds and still more to insects, by bright colors. And as "almost every fruit which is devoured by birds presents a strong contrast in color with the green foliage, in order that it may be seen, and its seeds disseminated," so the proportionally large size and the bright colors of the corolla, or in some cases the equally bright hues of adjoining parts of the flower, or of the inflorescence, are correlated to visiting insects,—have come to pass, as Darwin would say, in consequence of the visits of insects, through the advantages in vigor and productiveness gained by cross-fertilization. He is ready to adopt even the idea of Conrad Sprengel, which seemed to be so fanciful, that marks and streaks on the corolla serve as guides to the nectary: for, although insects are well able to discover the nectar without the aid of guiding marks, yet they are of service by facilitating the search and enabling insects to suck a greater number of blossoms within a given time, which is tantamount to greater opportunity for cross-fertilization.

That odors attract insects is certain and many flowers are both conspicuous and odoriferous, while others make up in fragrance what they lack in show. "Nägeli affixed artificial flowers to branches, scenting some with essential oils, and leaving others unscented: and insects were attracted to the former in an unmistakable manner."

"Of all colors white is the prevailing one; and of white flowers a considerably larger proportion smell sweetly than of any other color, namely, 14·6 per cent; of red, only 8·2 per cent are odoriferous. The fact of a larger proportion of white flowers smelling sweetly may depend in part on those which are fertilized by moths requiring the double aid of conspicuousness in the dusk and of odor. So great is the economy of nature, that most flowers which are fertilized by crepuscular or nocturnal insects emit their odor chiefly or exclusively in the evening. Some flowers, however, which are highly odoriferous depend solely on this quality for their fertilization, such as the night-flowering stock (Hesperis) and some species of Daphne; and these present the rare case of flowers which are fertilized by insects being obscurely colored."

"The shape of the nectary and of the adjoining parts are likewise related to the particular kinds of insects which habitually visit the flowers; this has been well shown by H. Müller by his comparison of lowland species, which are chiefly visited by bees, with Alpine species belonging to the same genera, which are visited by butterflies."

"Pollen contains much nitrogen and phosphorus—the two most precious of all the elements for the growth of plants—but in the case of most open flowers, a large quantity of pollen is consumed by pollen-devouring insects, and a large quantity is destroyed during long-continued rain. With many plants this latter evil is guarded against, as far as is possible, by the anthers opening only during dry weather, by the position and form of some or all of the petals, by the presence of hairs, etc.; also, as Kerner has shown in his interesting essay, by the movements of the petals or of the whole flower during cold and wet weather. In order to compensate the loss of pollen in so many ways, the anthers produce a far larger amount than is necessary for the fertilization of the same flower. I know this from my own experiments on Ipomœa, given in the Introduction; and it is still more plainly shown by the astonishingly small quantity produced by cleistogene flowers, which lose none of their pollen, in comparison with that produced by the open flowers borne by the same plants; and yet this small quantity suffices for the fertilization of all their numerous seeds. Mr. Hassall took pains in estimating the number of pollen-grains produced by a flower of the Dandelion, and found the number to be 243,600, and in a Pæony 3,654,000 grains. The editor of the 'Botanical Register' counted the ovules in the flowers of *Wisteria sinensis*, and carefully estimated the number of pollen-grains, and he found that for each ovule there were 7,000 grains." (pp. 376, 377.)

These are probably fair averages of the numerical ratio of pollen to ovules in flowers which are adapted to be fertilized by insect agency. Their meaning in "the economy of nature" is seen by a comparison on the one hand with *anemophilous*, i. e., wind-fertilized, flowers, in most of which there is a vastly greater disproportion between the numbers—compensating for inevitable waste—and on the other with *cleistogenous* flowers, namely those small and less developed blossoms which some plants produce in addition to the ordinary sort, and which fertilize as it were in the bud, necessarily by their own pollen. Here is no waste, and accordingly the anthers are very small, and the pollen-grains not many times more than the ovules: also such flowers are never brightly colored, never odoriferous, and they never secrete nectar.

The only advantages of this close-fertilization which we can think of are sureness and strict likeness; both of which are quite as well secured by budding-reproduction. Now, as cleistogene flowers are borne, we believe, chiefly and perhaps only, by species whose normal blossoms are adapted for insect-fertilization, they must be regarded as a subsidiary arrangement, a safeguard against failure of proper insect-visitation. As the volume before us amply shows, this failure is in general provided for by a more or less wide margin of self-fertilization in the very flowers which are adapted for crossing. In *Impatiens*, *Viola*, and the like, it is provided for by separate flowers, the special adaptations of which are unmistakable.

H. Müller appears to have shown "that large and conspicuous flowers are visited much more frequently and by many more kinds of insects than are small inconspicuous flowers. He further remarks that the flowers which are rarely visited must be capable of self-fertilization, otherwise they would quickly become extinct." Mr. Darwin's list seems to show that, as a rule, they are so; yet many very small flowers, like those of *Trifolium arvense*, and small and dingy ones, like those of *Asparagus*, are freely visited by bees; and, conversely, many large and conspicuous flowers which are frequented by insects are none the less self-fertilizable. Throughout we find that such things do not conform to arbitrary or fixed rules; and this favors the idea that the differences have been acquired. Mr. Darwin conjectures that the self-fertilizing capabilities of many small and inconspicuous flowers may be comparatively recent acquisitions, on the ground that, if they were not occasionally intercrossed, and did not profit by the process, all their flowers would have become cleistogenous, "as they would thus have been largely benefited by having to produce only a small quantity of safely protected pollen."

Mr. Darwin's experiments tending to prove that cross-fertilization between flowers on the same plant is of little or no use, he is naturally led to consider the means which favor or ensure their fertilization with pollen from a distinct plant. This must needs take place with diœcious plants, and is likely to occur with the monœcious, and is in some cases secured (as in Walnut and Hazelnut) by some trees being proterandrous and others proterogynous, so that they will reciprocally fertilize each other. In ordinary hermaphrodite species the expansion of only a few blossoms at a time greatly favors the intercrossing of distinct individuals, although, in the case of small flowers it is attended with the disadvantage of rendering the plants less conspicuous to insects. Our common Sundews furnish a good illustration of this. They abound wherever they occur, and are for a long while in blossom, but each plant or spike opens but one flower at a time. The fact of bees visiting the flowers of the same species as long as they can, instead of promiscuously feeding from the various blossoms nearest within reach, greatly favors such intercrossing. So does the remarkable number of flowers which bees are able to visit in a short time (of which mention will be made), and the fact that they are unable to perceive without entering a flower whether other bees have exhausted the nectar. Then dichogamy (the maturation of one sex in a hermaphrodite flower earlier than the other) is so prevalent that it may almost be regarded as the rule; and this ensures such crossing between few-flowered plants, and greatly favors it in the case of spikes, racemes, and the like. For, proterandry being the commonest arrangement, so that the younger flowers act as male, and the older as female, and bees habitually alighting at the bottom and proceeding upward, they carry the pollen from the upper and younger flowers to stigmas of the lower and older flowers of the next spike, and so on. Heterogonism (see this Journal for December, p. 82), which is less common, operates precisely like complete diœcious separation of the sexes in this respect, and with the advantage that all the individuals are seed-bearing. Most of the special arrangements peculiar to certain families, such as Orchids, or to plants—such as *Posoqueria*, with its wondrous mechanism for quickly stopping out access to the stigma when the pollen is violently discharged upon some insect, but opening the orifice the next day—are of a kind to favor the crossing of distinct plants. Prepotency of other pollen, which may accompany the other arrangements or exist independently, acts largely and powerfully toward the same end. Our author investigates this at some length: we cite for illustration a single but a strong case. The stigmas of a long-styled Cowslip were supplied with pollen from the same plant, and again, after twenty-four hours, with pollen of a short-styled, dark-red Polyanthus, a variety of the same species: from the resulting seeds twenty seedlings were raised, and all of them bore reddish flowers; so that the effect of the plant's own pollen, though placed on the stigmas twenty-four hours previously, was destroyed by that of the red variety. The same thing is shown by the impossibility in many cases of raising two varieties of the same species pure if they grow near each other. "No one who has had any experience would expect to obtain pure cabbage-seed, for instance, if a plant of another variety grew within 200 or 300 yards." And a veteran cultivator once had his whole stock of seeds seriously bastardized by some plants of purple Kale which flowered in a cottager's garden half a mile away. Mr. Gordon records a case of the crossing between Primroses and Cowslips through pollen carried by bees over more than two kilometers, or an English mile and a quarter.

We must copy the close of this section—long though it be—because of its capital illustration of the topic in hand, and for the teleological lesson which it teaches.

> "The case of a great tree covered with innumerable hermaphrodite flowers, seems at first sight strongly opposed to the belief in the frequency of intercrosses between distinct individuals. The flowers which grow on the opposite sides of such a tree will have been exposed to somewhat different conditions, and a cross

between them may perhaps be in some degree beneficial; but it is not probable that it would be nearly so beneficial as a cross between flowers on distinct trees, as we may infer from the inefficiency of pollen taken from plants which have been propagated from the same stock, though growing on separate roots. The number of bees which freqūent certain kinds of trees when in full lower is very great, and they may be seen flying from tree to tree more frequently than might have been expected. Neverthe-ess, if we consider how numerous are the flowers, for instance, on a Horse-chestnut or Lime-tree, an incomparably larger number of lowers must be fertilized by pollen brought from other flowers on the same tree, than from flowers on a distinct tree. But we should bear in mind that with the Horse-chestnut, for instance, only one or two of the several flowers on the same peduncle produce a seed; and that this seed is the product of only one out of several ovules within the same ovarium. Now we know from the experiments of Herbert and others that if one flower is fertilized with pollen which is more efficient than that applied to the other flowers on the same peduncle, the latter often drop off; and it is probable that this would occur with many of the self-fertilized flowers on a large tree, if other and adjoining flowers were cross-fertilized. Of the flowers annually produced by a great tree, it is almost certain that a large number would be self-fertilized; and if we assume that the tree produced only 500 flowers, and that this number of seeds were requisite to keep up the stock, so that at least one seedling should hereafter struggle to maturity, then a large proportion of the seedlings would necessarily be derived from self-fertilized seeds. But if the tree annually produced 50,000 flowers, of which the self-fertilized dropped off without yielding seeds, then the cross-fertilized flowers might yield seeds in sufficient number to keep up the stock, and most of the seedlings would be vigorous from being the product of a cross between distinct individuals. In this manner the production of a vast number of flowers, besides serving to entice numerous insects and to compensate for the accidental destruction of many flowers by spring-frosts or otherwise, would be a very great advantage to the species; and when we behold our orchard-trees covered with a white sheet of bloom in the spring, we should not falsely accuse Nature of wasteful expenditure, though comparatively little fruit is produced in the autumn."

The Horse-chestnut is not altogether a well-chosen example, for in it, as in our Buckeyes, a very large proportion of the flowers in the thyrsus are usually male, with barely a vestige of pistil. These serve, however, to increase the show, in the manner here illustrated, as well as to furnish abundance of pollen.

The section on anemophilous (wind-fertilized) plants,—their interest as survivals of the earlier phænogamic vegetation,—the speculation as to how, when flying insects came to prevail, an anemophilous plant may have been rendered entomophilous,—how pollen, being a most nutritious substance, would soon have been discovered and devoured by insects, and by adhering to their bodies be carried from anthers to stigma and from one flower to another,—how a waste secretion, such as honey-dew or glandular exudations, may have been developed into nectar and utilized as a lure,—the interesting illustrations of the vast amount of pollen produced by anemophilous plants, and the great distances to which their light pollen is often carried by the wind,—all these inviting topics we must now pass by.

In passing we note the remark that "the excretion of a sweet liquid by glands seated outside of a flower is rarely utilized as a means of cross-fertilization by the aid of insects;" and the sole exception alluded to is that of the bracts of *Marcgraviaceæ.* But a parallel case is afforded by many species of *Euphorbia*, and notably in a striking species cultivated in conservatories, under the name of *Poinsettia.* Here the attraction to the eye is supplied by the intense red coloration of ordinary leaves placed next to the inflorescence, and that to the palate or tongue (if either term may be allowed), by a large cup-shaped gland on the side of the involucre, which contains or surrounds the naked and greatly simplified flowers of both sexes.

That anemophilous plants are prevailingly diclinous (either monœcious or diœcious) is speculatively connected with their antiquity; that they are very largely trees or shrubs is because "the long life of a tree or bush permits of the separation of the sexes with much less risk of evil from impregnation occasionally failing, and seeds not being produced, than in the case of short-lived plants. Hence it probably is, as Lecoq has remarked, that annual plants are rarely diœcious." The number of anemophilous species is comparatively small, but that of individuals of the species strikingly large, so that they form of themselves, in cold and temperate regions, where plant-fertilizing insects are fewer, either vast forests, as of Coniferæ, birches, beeches, etc., or meadows, and glades, as of grasses, sedges, and rushes. Being thus either necessarily or prevailingly cross-fertilizable and gregarious, it is not wonderful that they should hold their own unchanged in various parts of the world. Still their advantage is gained at the expense of the production of an enormous superfluity of pollen, a costly product; and, when diœcious, half the individuals produce no seed. Hermaphroditism with dichogamy, or some equivalent, and transportation by an appeal to the senses and appetites of insects, secures all the advantages with least expenditure. The earliest fertilization in plants took place by the locomotion of the fertilizing or even of the fertilized material, in manner of most of the *Algæ:* mainly losing this as vegetation became terrestrial, the transportation was committed to the winds, and finally in the higher plants more economically consigned to insects.

The eleventh chapter, on the habits of insects in relation to the fertilization of flowers, is one of the interesting and readable, although the shortest. It appears that the prince of naturalists, Aristotle, had observed more than 2000 years ago that the hive-bee visited the flowers of the same species as long as possible before going to a different species. This holds true of all kinds of bees and certain other insects, generally, but not absolutely. Although, as Lubbock has recently proved, bees are much guided by color, yet they hold to the practice just mentioned in spite of difference in this respect, being botanists enough to know that color is not a good specific character. Mr. Darwin has repeatedly seen humble-bees flying straight from a red Fraxinella to a white variety, from one Larkspur to a different colored variety, and the same as to Primroses and Pansies. But two species of Poppy were by some bee treated as one; and H. Müller traced hive-bees from blue hyacinths to blue violets. On the other hand, Darwin's bees fly straight from clump to clump of a yellow Œnothera without turning an inch from their course to Eschscholtzias with yellow flowers which abound on either side. This constancy to species, however, is manifested only when their flowers abound; a fact which may have led Mr. Darwin to his explanation of the reason of it.

> "The cause probably lies in insects being thus enabled to work quicker; they have just learnt how to stand in the best position on the flower, and how far and in what direction to insert their proboscides.* They act on the same principle as does an artificer who has to make half-a-dozen engines, and who saves time by making consecutively each wheel and part for all of them. Insects, or at least bees, seem much influenced by habit in all their manifold operations; and we shall presently see that this holds good in their felonious practice of biting holes through the corolla." (p. 420.)

As to this latter practice —

> "The motive which impels bees to gnaw holes through the corolla seems to be the saving of time, for they lose much time in climbing into and out of large flowers, and in forcing their heads into closed ones. They were able to visit nearly twice as many flowers, as far as I could judge, of a *Stachys* and *Pentstemon* by alighting on the upper surface of the corolla and sucking through the cut holes, than by entering in the proper way. Nevertheless each bee before it has had much practice, must lose some time in making each new perforation, especially when the perforation has to be made through both calyx and corolla. This action therefore implies foresight, of which faculty we have abundant evidence in

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* H. Müller had come to the same conclusion.

their building operations; and may we not further believe that some trace of their social instinct, that is, of working for the good of other members of the community, may here likewise play a part? Many years ago I was struck with the fact that humble-bees as a general rule perforate flowers only when these grow in large numbers near together," etc., etc. (p. 433.)

It appears that the cutting of these holes is done only by humble-bees, never by hive-bees. Yet the latter are quick to take advantage of them.

"In the early part of the summer of 1857 I was led to observe during some weeks several rows of the scarlet kidney-bean (*Phaseolus multiflorus*), whilst attending to the fertilization of this plant, and daily saw humble- and hive-bees sucking at the mouths of the flowers. But one day I found several humble-bees employed in cutting holes in flower after flower; and on the next day every single hive-bee, without exception, instead of alighting on the left wing-petal and sucking the flower in the proper manner, flew straight without the least hesitation to the calyx, and sucked through the holes which had been made only the day before by the humble-bees; and they continued this habit for many following days. Mr. Belt has communicated to me (July 28th, 1874) a similar case, with the sole difference that less than half of the flowers had been perforated by the humble-bees; nevertheless, all the hive-bees gave up sucking at the mouths of the flowers and visited exclusively the bitten ones. Now how did the hive-bees find out so quickly that holes had been made? Instinct seems to be out of the question, as the plant is an exotic. The holes cannot be seen by bees whilst standing on the wing-petals, where they had always previously alighted. From the ease with which bees were deceived when the petals of *Lobelia Erinus* were cut off, it was clear that in this case they were not guided to the nectar by its smell; and it may be doubted whether they were attracted to the holes in the flowers of the Phaseolus by the odor emitted from them. Did they perceive the holes by the sense of touch in their proboscides, whilst sucking the flowers in the proper manner, and then reason that it would save them time to alight on the outside of the flowers and use the holes? This seems almost too abstruse an act of reason for bees; and it is more probable that they saw the humble-bees at work, and understanding what they were about, imitated them and took advantage of the shorter path to the nectar. Even with animals high in the scale, such as monkeys, we should be surprised at hearing that all the individuals of one species within the space of twenty-four hours understood an act performed by a distinct species, and profited by it." (pp. 430, 431.)

But we must cut short our citations and remarks; passing by one of the most important points, relative to the amount of fertilizing work done by insects, namely, the evidence of the extraordinary industry of bees and the number of flowers visited within a short time; which, as well as the distance to which pollen is sometimes transported, is far greater than one would have supposed. But the volume is reprinting by the Appletons, and will soon be within the reach of all,—along with a new edition of the orchid-fertilization book, the proper supplement to the present work, relating as it does to the class of plants in which the adaptation for fertilization by insects is carried to the highest degree of specialization and perfection.

ART. XVII.—*Note on Microdiscus speciosus;* by S. W. FORD.

IN my original description of this interesting Trilobite (this Journal, August, 1873) it is stated that the thorax is composed of four equal segments. The description, in so far as relates to this part of the animal organization, was drawn up from the study of a single specimen, showing the head, thorax and pygidium in nearly their natural positions, and apparently offering decisive testimony as to the true number of body-rings. Somewhat more than a year ago, however, I obtained from the Troy beds another specimen, of almost precisely the same dimensions, showing clearly but *three* segments in the thorax; and, subsequently, a much larger specimen showing the same number. This led me to re-examine, more critically, the specimen employed in the original description, when it was found that the head had slipped slightly forward, and that what I had regarded as the first pleura (all of the pleuræ of one side, as well as one-half of the head, being enveloped in the matrix) was a fragment of some foreign body that had fallen into the gap thus made. The deception, in the first instance, was rendered all the more complete from the fact that, by the displacement of the head alluded to, the articular fold of the first body-ring, which is ordinarily wholly hidden from view by the backward prolongation of the glabella, was exposed, thus making a very good case for a fourth segment. I now consider it certain that this species has never more than three body-rings. I have in my collection a small rolled-up specimen showing the extremities of but two body-segments, and I was at first led to think it possible that we had in this species an example of the metamorphoses of Trilobites, concerning which Barrande has taught us so much. But as I have observed since this specimen was obtained, an individual of even smaller size, with three perfectly formed body-segments, this notion is without foundation at the present time. I should here also add that the last body-ring is not, as I originally believed it to be, firmly soldered to the pygidium.

It is a remarkable fact that, under each of the four trilobitic genera represented in the Troy Primordial, viz., *Olenellus*, *Conocoryphe*, *Microdiscus* and *Agnostus*, there should be found, in this fauna, a species affording an example of a well-marked departure from the usual structure of the genus to which it belongs. Thus *Microdiscus speciosus* has but three body-rings, as already stated, while all the other described species of the genus whose thorax is known have four; *Agnostus nobilis* has but one body-ring, while nearly all of the other species have two; *Conocoryphe trilineata*, with its singularly-cleft caudal margin stands widely apart from all the other certainly known species of the genus; while *Olenellus asaphoides*, unlike the other described species in which the thorax has been observed, has none of its anterior pleuræ extravagantly prolonged as compared with the others. In this respect this latter species, as Barrande has already indicated, sustains the same relation to the Vermont forms of the genus as do the Swedish *Paradoxides* to their Bohemian allies.

November 20th, 1876.

ART. XVIII.—*On Water Courses upon Long Island;* by ELIAS LEWIS, Jr.

IT has been estimated that of the forty-two inches of average annual rainfall upon Long Island more than three-fourths sinks directly into the porous soil. The excess which occurs when the fall is unusually heavy, or the surface frozen, makes its way into the innumerable valleys which traverse its surface. These valleys may therefore be considered as lines of surface drainage, the principal of which have their source on the high grounds near the center of the island, whence a portion of them extend northward toward Long Island Sound, others southward to the bay or ocean.

On the north side of the island, of which we shall first speak, many small lateral valleys open into the larger ones, cutting the surface into a series of valleys and hills, forming a landscape exceedingly beautiful and picturesque.

The high grounds referred to comprise a range of hills which extend more than sixty miles in a direction parallel with that of the island, and which vary from 150 to 384 feet in height. This range is called, absurdly enough, the backbone of the island. It consists, however, of glacial drift, with boulders, many of immense size, but is wholly without rock in place. It is upon this range, quite at the top in many instances, that the principal water courses have their source. From these elevations they extend as broad deep valleys, well cultivated or wooded, rarely presenting evidence of recent erosion.

An inquiry is suggested, how and when were they formed? The surface waste of water from the present volume of rainfall seems wholly inadequate to produce them. Much of this percolates the soil after reaching the valleys, and in many instances the bottom of the valleys, which is usually of gravels and sand, is covered deeply by an accumulation of sedimentary matter because the flow of water through them has not been sufficient to maintain them at their original depth. In the great watercourse which opens at Glen Cove there occurs, three miles southward from its termination, a deposit of fine clay six feet or more in thickness, and thirty feet below accumulated sediment in the valley. The fact that such deposits occur in the old water courses suggests, we think, feeble energy of erosion, and points to a time when it was more active than now.

The formation and maintenance of a valley implies that the material which filled it, or which might have filled it, has been removed by a stream of sufficient volume to accomplish the work. A quantity of rainfall is conceivable which would erode and deepen the valleys in question, and that such occured at a former period is quite possible, but we insist that while some erosion must occur when water moves over the surface of the ground, that the great development of these valleys, especially at their source, and upon the highest grounds, is not explained by the present surface waste. The watershed of the island upon the hills is narrow; frequently a few rods, or feet separates the source of a valley extending northward from one running southward.

We are inclined to look to an agent other than rainfall for the development of the surface sculpture of Long Island. Excepting its lower beds which may consist of Tertiary or Cretaceous deposits, or of both, the island is a glacial moraine,—a mass of debris both unmodified, and in every stage and form of modification. The surface valleys were evidently watercourses for sub-glacial streams supplied by the ever wasting ice while it still lay upon the coast. From this cause a deep erosion of the highest grounds was possible, and the general contour of the surface determined. The direction and course of all the principal valleys indicate their common origin. So deeply marked and well defined are they that little change in their general aspect seems to have taken place since the disappearance of the ice sheet from the coast. If from the surface valleys we turn to the similar but vastly greater ones on the north side of the island which now constitute the series of magnificent harbors upon its coast, we find proof that they too had their origin in glacial times. These harbors are eight in number, and although in glacial drift are as truly fiords as those along the rocky coast of Greenland. They extend into the island from three to six miles, they are from half a mile to a mile and a half broad and are in the deeper portions from ten to twenty-five feet deep. They were probably deeper when free from sediment. In a few instances where tidal currents are strong the water is from thirty to fifty feet deep. The land on either side of the fiords is from a few feet to as much as 200 feet above tide, and the valleys continue long distances inland beyond where the tides reach. Many lateral valleys open into these, evidently cut by glacial streams. It is extremely probable that these great fiords were, at an early stage of the formation of the island, water-courses opening to the ocean, and were maintained as such until filled by accumulating drift. This may have occurred while the ice sheet still lay over the region, and the streams were under or sub-glacial ones. When however the valleys were finally filled with drift at their terminus the waters were arrested, and thenceforth discharged eastward and westward through, what is now, Long Island Sound.

There is no evidence that the fiord valleys have changed in their general contour since the glaciers disappeared. The facts undoubtedly imply that the coast stood at a greater elevation than now, for the glacial-fed streams must have swept the fiord valleys to their bottom. But Prof. Dana has shown long since that the Glacial period was probably one of elevation of Northern lands.

There is reason for the conclusion, however, that some deepening of the principal surface valleys has taken place subsequently to the disappearance of the ice, which may be attributed to streams. There occurs in many instances fragmental deposits of sand and gravel along their banks, ten to twenty or more feet above the bottom, which seem to be remains of flood plains, and indicate erosion to that extent. If this be correct, a more abundant rainfall at a former period is suggested, and it may have occurred while the ice still lay upon New England. Chilled by its presence the vapor-laden air from the ocean might have dropped its moisture in more abundant rain or snow upon the coast, and local accumulation of snow upon the hills during winter may have aided in swelling the eroding streams.

The water-courses which open southward from the central hills of the island extend over a nearly uniform plain; they are of moderate depth, rarely greater than twenty feet, have few tributaries, and are quite direct and continuous from the hills to the bay. They are over a formation geologically different from that on the north side of the hills, it being stratified gravel and sand, proving the presence of the ocean over the region subsequent to the deposit of the drift. The stratified beds occur at all heights up to 260 feet above tide, and imply a submergence of the coast to that extent. There still remained, however, many elevations above the ocean (or if they were submerged their contour was not altered), for they now show the same development of old valleys as we have noticed on the north side of the hills. This is important in explaining the newer valleys over the stratified, and newer beds. We have traced several of these to their source, and find that in each instance the new valley is a continuation of an old one. These new valleys are called locally "plain valleys," because they traverse the plains, and there are thirty of them between East New York and Riverhead, a distance of fifty miles.

It is easy to see why the new valleys are continuous with those upon the higher grounds, as the precipitation upon the region would flow into the old valleys, giving direction to the surface waste in streams. These at the period of submergence, which was probably the closing of the Glacial, or opening of the Champlain period, would continually empty into the bay or ocean near. As the coast arose from the water the shore line receded, but the streams would still reach it, and slowly but surely erode the plain valleys in question. It thus appears that the water courses over the modified drift of the plains have their origin in older valleys worn by glacial torrents in a preceding age.

There is a source of valley erosion on both sides of Long Island which has not yet been mentioned. It arises from springs fed from rainfall, which break out and flow during the whole, or part of the year in some of the valleys. These springs are from under-drainage. On the south side of the island they appear from one to three miles from the coast, forming streams of great beauty and purity. It is from this source that the city of Brooklyn is supplied with its wonderfully pure water. There is reason to conclude that the springs broke out farther inland at a former period. On the north side of the island springs appear in some of the valleys from which small streams flow a part of the year. In both instances, however, we should not expect the cropping out of springs, in valleys, until the valleys were formed. It is because, in most instances, the valleys have been cut down, to the level of saturation, that springs appear, and if at any period they cropped out farther inland in the valleys, or upon a higher level, it was because the level of saturation was higher than it now is. Any subsequent lowering of it has arisen from a diminished supply of water, consequent upon diminished precipitation.

In review the following conclusions seem to be sustained :—

1. The formation of the principal valleys about the hills of central Long Island and northward to the Sound was concurrent with the closing period of the ice over the region, but some deepening has taken place by water from rainfall, both from its surface waste, and from under-drainage, forming springs in some of the valleys.

2. The great fiord valleys were contemporaneous with the progress of the ice period.

3. The "plain valleys" have been formed by streams from both surface and under-drainage, and originated in older valleys which determined the flow of the eroding waters.

4. A further conclusion is suggested that the volume of precipitation over the region was greater at a former period than at the present time.

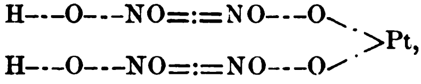
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Purification of Hydrogen gas.*—Although the use of hydrogen gas as a reducing agent in analytical operations has become quite general since it was proposed by Rose, yet no method of perfectly purifying this gas has been described. **Schobig** has made a series of experiments upon the use of a saturated solution of potassium permanganate for this purpose, the results of which appear to be quite satisfactory. The impurities which were introduced were the hydrogen compounds of sulphur, phosphorus, arsenic, antimony and carbon. The permanganate was used as neutral, acid, and alkaline solution, contained in a Bunsen wash-bottle. Careful examination of the gas after passing through a layer 10 cm. thick of the solution, either when only a single impurity was present or when all were mixed together, failed to show a trace of foreign substance. Hydrogen sulphide was found to be best removed by an alkaline solution; the other substances by a neutral or acid one. Even coal gas after passing slowly through a thickness of ten centimeters of the solution, deposited no carbon when passed through an ignited tube, the carbon being oxidized to carbon dioxide. As to the question whether hydrogen itself is not oxidized by the permanganate, the author made comparative experiments with neutral, acid and alkaline solutions, which showed that oxidation does take place, the maximum rate being about a third of a cubic centimeter per hour under the conditions employed, and this in the neutral solution. With the hydrogen thus perfectly purified the author succeeded in reducing a silver solution, in the dark and in the absence of organic matter. In dilute solutions the silver separated as a fine powder; in concentrated ones, it formed a mirror.—*J. pr. Ch.*, II, xiv, 289, Oct., 1876. G. F. B.

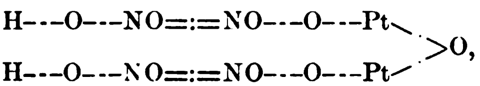
2. *On Hypovanadic Oxide and its Compounds.*—CROW has examined, under Roscoe's direction, the modes of production and the properties of the hypovanadic oxide of Berzelius (vanadium tetroxide) and some of its compounds, the vanadium being determined analytically either by titrition with permanganate or by fusing and weighing as pentoxide. Hypovanadic oxide, prepared by heating the chloride to redness in an atmosphere of carbon dioxide, is nearly pure, containing about 95 per cent of V_2O_4. It is a dark-green amorphous powder, insoluble in water, soluble in acids or alkalies, and absorbs oxygen from the air. The hydrate, obtained by precipitating a solution of the sulphate or chloride with sodium carbonate, filtering in an atmosphere of carbon dioxide and drying in a vacuum, is a black amorphous mass, having the composition $V_2O_4, (H_2O)_7$. Two trisulphates are described, one with seven, the other with four molecules of water, both of which are light blue deliquescent crystalline powders. Two similar disulphates were also obtained. The chloride, $V_2O_4Cl_2, (H_2O)_5$, prepared by dissolving the pentoxide in hydrochloric acid, reducing the solution with hydrogen sulphide, and evaporating, is a brown amorphous deliquescent mass, which yields a blue solution. Potassium hypovanadate, $K_2O.(V_2O_4)_2, (H_2O)_7$, is deposited in reddish-brown crystalline scales or needle-shaped crystals, when the sulphate or chloride is treated with excess of potassium hydrate and allowed to stand, closely stoppered, some hours. The sodium salt is similar. The ammonium, barium, lead and silver salts, the last two of which are anhydrous, are also described as brown or black precipitates.—*J. Chem. Soc.*, xxx, 453, Nov., 1876. G. F. B.

3. *On Plato- and Diplato-nitrites.*—NILSON has examined at length the peculiar double nitrites of platinous oxide and potassium, sodium, ammonium, silver, mercury and barium described by Lang, and, adopting Blomstrand's view that they are paired compounds of quinquivalent nitrogen, he considers them to contain the bivalent radical platotetranitrosyl, the acid from it,



$$\left.\begin{array}{l}\text{H---O---NO}{=}{:}{=}\text{NO---O}\\ \text{H---O---NO}{=}{:}{=}\text{NO---O}\end{array}\right\rangle\text{Pt},$$

being called platotetranitrosylic acid or platonitrosylic acid, and the salts platonitrites. He describes also new compounds containing another similar radical, in which, to the four nitrosyl groups, there are two platinum atoms and one more atom of oxygen. This radical he calls diplatotetranitrosyl, the free acid,



$$\left.\begin{array}{l}\text{H---O---NO}{=}{:}{=}\text{NO---O---Pt}\\ \text{H---O---NO}{=}{:}{=}\text{NO---O---Pt}\end{array}\right\rangle\text{O},$$

being diplatonitrosylic acid and the salts diplatonitrites. Nilson has prepared the potassium, rubidium, cæsium, ammonium, thallium, sodium, lithium, silver, calcium, strontium, barium, lead, magnesium, manganous, cobaltous, nickelous, ferrous, cupric, zinc, cadmium, mercurous, aluminum, yttrium, erbium, cerium, lanthanum and didymium platonitrites, and silver, glucinum, aluminum, chromous, indium and ferric diplatonitrites. The former salts are for the most part beautifully crystallized, though the solution must be concentrated, since they are very soluble in water. The diplatonitrites, with the exception of the silver salt, which is green, are characterized by their brilliant red color.—*Ber. Berl. Chem. Ges.*, ix, 1722, Dec. 1876. G. F. B.

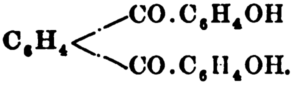
4. *On the behavior of Palladium in the Alcohol flame.*—Wöhler, as early as 1824, having observed that palladium, either in the form of foil or sponge, when heated in an alcohol flame covered itself with a thick layer of carbon, rendering the metal porous and brittle, and having, upon Graham's discovery of the remarkable occlusion of hydrogen by this metal, assumed this as the cause of the phenomenon observed by him, has now sought to verify the supposition by passing pure dry ethylene gas over palladium sponge, first at 100°, then at higher temperatures; but no result was obtained until a red heat was reached, when carbon was deposited and hydrogen evolved; the temperature being below that, however, at which ethylene itself decomposes. Since palladium has no affinity for carbon, the author suggests that the result observed may be due to an alternate union with hydrogen and separation therefrom. He also describes a convenient apparatus for showing the absorption of hydrogen by palladium and its evolution on heating.—*Ber. Berl. Chem. Ges.*, ix, 1713, Dec. 1876. G. F. B.

5. *On two new Dichlornaphthalenes.*—The α and β varieties of dichlornaphthalene, described by Faust and Saame, have fusing points of 35–36° and of 68° respectively; the γ variety, obtained by Atterberg, fuses at 107°. Cleve has prepared two new forms of this substance, δ-dichlornaphthalene, fusing at 114°, and ϵ-dichlornaphthalene, fusing at 135°, by the action of phosphoric chloride upon the calcium salts of the two napthalene-disulphonic acids described by Ebert and Merz. The former body is easily soluble in boiling alcohol, from which it crystallizes in broad brilliant plates. The latter is much less soluble and crystallizes in brilliant prisms.—*Bull. Soc. Ch.*, II, xxvi, 244, Oct. 1876. G. F. B.

6. *Emodin from the bark of Rhamnus frangula.*—Liebermann and Waldstein have examined the crystallized substance contained in the bark of *Rhamnus frangula* (buckthorn) with a view to ascertain the relation of the frangulinic acid of Faust, which he had recognized as an anthracene derivative, to the other isomers of alizarin. The crude material was obtained from Merck, and was prepared by extracting the bark with dilute soda solution, precipitating with hydrochloric acid, and after repeating this process, recrystallizing from alcohol. It was a red crystalline powder containing small quantities of some glucoside. Purified by recrystallization from glacial acetic acid, it gave beautiful orange silky needles, which after sublimation and crystallization

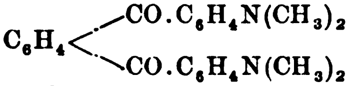
from absolute alcohol gave on analysis the formula $C_{15}H_{10}O_5$, which is that also of emodin, obtained from rhubarb root, as Liebermann had shown. The acetyl-derivative was prepared, and found to be acetyl-emodin. The hydrocarbon obtained by distilling it with zinc dust, was a mixture of anthracene with methyl-anthracene, as its oxidation products showed. A close comparison proved the substance to be identical with emodin. The bark contains only about 0·2 per cent of it. Whether frangulinic acid also actually exists in the bark, the authors promise further investigation to determine.—*Ber. Berl. Chem. Ges.*, ix, 1775, Dec. 1876. G. F. B.

7. *On the Phthaleins of tertiary aromatic Bases.*—The remarkable analogy between dimethylaniline and phenol, shown in the production by Michler of a new body from the former by a reaction similar to the synthesis by Kolbe of salicylic acid from the latter, has led Fischer to follow up this analogy and to produce a phthalein of dimethylaniline corresponding exactly with the phthalein of phenol, one of Baeyer's remarkable bodies. This resemblance is clearly shown in the following formulas of these substances:



$$C_6H_4<\begin{matrix}CO.C_6H_4OH\\CO.C_6H_4OH.\end{matrix}$$

Phthalein of phenol.



$$C_6H_4<\begin{matrix}CO.C_6H_4N(CH_3)_2\\CO.C_6H_4N(CH_3)_2\end{matrix}$$

Phthalein of dimethylaniline.

The new phthalein was obtained by the action of dimethylaniline upon phthalic chloride. The mixture heats, foams violently, and becomes dark-green in color. Water is added, the excess of dimethylaniline is removed by evaporation, and there is left a resinous mass which, crystallized from chloroform, gives greenish-yellow needles. It forms mono- and di-chlorides, chloro-platinates and picrates, the former of which are green, the latter yellow. Reduced with zinc dust, it gives a colorless base, like the phthaleins of the phenols.—*Ber. Berl. Chem. Ges.*, ix, 1753, Dec. 1876. G. F. B.

8. *Standard Meter.*—M. G. Matthey presented to the French Academy at their meeting of Dec. 4th the platinum-iridium 4-meter bar, constructed for the International Geodetic Association. The metals were prepared by MM. Sainte-Claire Deville and Debray, and each time 450 ounces of platinum and 55 (50 ?) ounces of iridium were used. Five ingots thus prepared were cut in small pieces by a hydraulic press. The fragments were then melted in the same furnace and kept in a liquid state for a long time by a flame of oxygen and burning gas. The new ingot was forged and then rolled. The faces of the hammer and anvil were of polished steel constantly rubbed. The sheets after being well scraped were again melted in a rectangular furnace and produced a very homogeneous mass free from cracks or roughness on the bottom, sides or top. After the first forging a bar was obtained 35 cms. long, 7·5 cms. wide and 2·5 cms. thick, which weighed 15·105 kgs. and had a specific gravity of 21·522. A third of the

bar was cut off and the other two-thirds when forged and well annealed had the following dimensions: Length, 95 cms.; breadth, 2·5 cms.; thickness, 2 cms. Its weight was then 10·315 kgs. and its specific gravity, 21·648. The bar was next rolled between polished cylinders and brought to very nearly the required dimensions, of length 410 cms., breadth 2·1 cms., and thickness ·5 cms. Finally, a perfectly rectangular form was given to the bar by drawing it several times through a hole in a plate of steel. Each time the bar was heated to the highest temperature by a very large gas blowpipe fed with oxygen, and it was passed through the same hole until a force was no longer required to draw it through and it no longer underwent a sensible elongation. Each time when hammered, rolled or drawn, the metal, heated either in a great muffle or by the blowpipe, was cleaned by melted borax and by concentrated chlorhydric acid. The rule ought to receive from the makers, MM. Brünner, the high degree of polish of which it is susceptible, and which in its present rough condition it does not possess.

M. Deville in commenting on this communication gave the following result of an analysis of a portion of this alloy: Platinum, 89·42; iridium, 10·22; rhodium, ·16; ruthenium, ·10; iron, ·06; total, 99·96. The density computed from that of these components was 21·515; that observed, 21·516. A second analysis gave by computation 21·51; by observation, 21·508. He then exhibited two tubes of the same alloy made from the portion cut off from the bar as described above. These tubes are closed by spherical cups, of which one terminates in a capillary tube which enables the interior to be put in communication with Regnault's manometer. Each of these tubes is more than a meter long and one of them has a capacity of over a liter. This is to serve as an air thermometer for the determination of the boiling points of various liquids under known pressures. These tubes will have on their surfaces two lines a meter apart. The deviation compared with that of the second tube which will be kept in ice, will enable the exact temperature to be calculated. This will carry out a suggestion long since made by Regnault, and which has been applied to the measurement of high temperatures. It will be interesting to apply this method to the measurement of the lowest temperatures so far attained. These researches have an important bearing on metrology. All substances capable of being tempered, as glass and steel, undergo a change with time. Others which like zinc crystallize with changes of temperature also change with time. Hyaline quartz, according to Mr. Wild, appears exempt from this change. Does the platinum-iridium act like steel, zinc or quartz? This question will be solved by weighing the quantity of water which one of these tubes will contain at 0°. After all the experiments in which the temperature will be varied between very wide limits the capacity of the tube will be again measured. Each change of three milligrams in the weight of the meter will represent the volume of the tube corresponding to a change of oneousandths of a millimeter in the distance between the two lines rked on the tube.—*Comptes Rendus*, lxxxiii, 1090. E. C. P.

9. *Films of Water.*—Mr. Tylor read a paper before the Lon- n Physical Society on the cohesion and capillary action of films water under various conditions. The author endeavors to minate the action of all forces except that of gravity by im- ersing his "valves" in water. The models which he exhibited nsisted of glass tubes about three inches in diameter and six ches high, filled with water and containing each a piston, which, being raised, was capable of lifting by cohesion a heavy mass metal, the nature of the surfaces in contact differing in the sev- al instruments. From experiments with them he concludes at the time during which a heavy valve can be supported pends upon the size of the surface of contact, the difference of essure within and without the moving parts, and the smooth- ss of the valve. On the contrary, dry bodies, such as Whit- rth's surface planes, will adhere for an indefinite period. Mr. ylor considers that the supporting of a body in water is due to a fference of pressure in the water itself, and he adduced Giffard's jector as showing that such differences can take place. He has so studied the form of a drop of water at a tap, and considers at when a fly walks on a ceiling its weight acts in the same anner as the heavy valves in the models exhibited.—*Nature*, xv, 1. E. C. P.

10. *Fog-Signals.*—Prof. Henry at the recent meeting of the nited States National Academy communicated some additional cts obtained in his long-continued and elaborate researches con- rning sound in relation to fog-signals. His principal investiga- on this year had reference to the divergence of sound, especially to the phenomenon known as the Ocean Echo. To test the ex- anation given by Prof. Tyndall, requiring reflection from the r, the trumpet of a siren was turned directly to the zenith. The ast was exceedingly intense, but no echo was heard from the olongation of the axis of the trumpet, i. e., from the zenith. loud echo was, however, heard from the whole circumference the horizon, half of which was on land, the other half on water. his was repeated many times, and always with the same result. one case a small cloud passed directly across the zenith, from hich a few drops of rain fell into the mouth of the trumpet; ill no sound was heard from the zenith, although sound con- nued to be heard from around the horizon. In this case on ac- unt of the divergence of the sound, portions of waves in every rection must have descended to the horizon, and as some of ese must have reached the plane of the ocean in a path curv- g inward toward the source of sound, they would, when they ached the ear of the observer in the vicinity of the source, seem if coming from a point in the horizon, and hence would give se to the phenomenon of the ocean echo. Rays of sound at dif- rent distances from the ear could be reflected from the surface the ocean and thus give rise to a prolonged echo. This is in

accordance with the fact observed during last summer, that a blast of five seconds' duration gave an echo that was prolonged twenty seconds. This could only be produced by ordinary reflection from a series of surfaces placed at different distances, an arrangement of the material of the atmosphere which (on the doctrine of probabilities) would not be of frequent occurrence.—*Nature*, xv, 129. E. C. P.

11. *The Siphon Recorder and Automatic Curb Sender.*—An illustrated article showing the practical as well as the theoretical construction of these instruments appears in *Nature* for Nov. 30th, 1876 (xv, 101). For some time after the introduction of submarine telegraphy the mirror galvanometer was the only instrument delicate enough to receive the messages transmitted through a long cable. The clerks must here read the message by watching the deviations of a spot of light from side to side. The siphon-recorder serves to draw a sinuous line by which the message is recorded in permanent form. The speed of sending will be greatly increased by sending after each current a second in the opposite direction. This is effected by the curb-sender. Three rows of holes are punched in a long strip of paper, the central row serving to carry the paper through the machine and the row on one side corresponding to the dots or positive currents, that on the other to the lines, or negative currents. When the paper passes through the machine it receives by clock-work a uniform motion. Two prickers are placed so as to correspond to the two outer rows of holes. When a hole passes, the corresponding pricker falls into it, and in so doing lifts a spring through an opening in the rim of a revolving wheel. The spring being caught in the rim of the wheel is obliged to remain there until the wheel makes one complete revolution and the opening in the rim returns to free it. The wheel makes one revolution while one space passes the pricker. When the spring is lifted into the rim of the wheel it makes connection between the battery and another set of springs, by which a current is sent through the cable, and shortly after it a second current is sent in the opposite direction. The currents are reversed when the other pricker acts. E. C. P.

II. GEOLOGY AND MINERALOGY.

1. *Report on the Transportation route along the Wisconsin and Fox Rivers in the State of Wisconsin, between the Mississippi River and Lake Michigan;* by GOUVERNEUR K. WARREN, Major of Engineers and Brevet Major General, U. S. Army. 114 pp. 8vo, with many maps. Senate Ex. Document, No. 28, 44th Congress. Washington, 1876.—General Warren's Report gives, first, a history of geographical knowledge and surveys respecting this old transportation route, then an account of the work that has been done by him or under his direction. We take the following facts from it.

The two streams—the Fox River which joins Lake Michigan at ıead of Green Bay, and the Wisconsin, which empties into lississippi at Prairie du Chien, come within a mile and a half ıe another, at bends in each, near Portage City, where a ıte ridge lies near the surface. The summit of this Portage n is about 218 feet above Lake Michigan, and 188 above the ssippi, and the summit of this water level 208½ and 178½

The stream from Portage eastward (Fox River) passes ıgh Lake Winnebago (besides three smaller lakes), with a ınt of 39 feet, and then plunges down the remaining 169½ ılong a limestone gorge whose sides are fifty feet or less in ıt.

e region of Lake Winnebago is bordered on the west by a ılluvial plain, partly marshy, which is represented on a map ıching thirty miles west, and then extending in broad areas north along Wolf River, and southwest along the Upper Fox rd Portage, and hence as including the other small lakes of oute. General Warren explains the origin of these features ıe view that the whole alluvial area was originally a lake; at h time the waters drained off over the low granite ridge at ıge through the Wisconsin River to the Mississippi.

e height of this divide now existing at Portage is only a few so that the westward flow would have necessarily taken place the waters at the height required to make the lake. After- there was a subsidence to the northeastward which deter- d the flow in that direction (where the loose material easily way, while granite resisted wear in the opposite course) ı the limestone slope, toward Green Bay, making thus the ›r Fox River channel. That this subsidence occurred after lacial period is stated to be shown by the absence of glacial from the alluvial plain.

e facts are of the highest interest because they tend to prove the subsidence of the Champlain period (that following the .al), so well sustained for the eastern part of the Continent, in igher latitudes, by facts along the coast of New England, ador, and regions farther north, and also on the shores of Champlain and the St. Lawrence, actually affected also the ior of the Continent, for which it is so difficult to find evidences ange of level.

neral Warren obtained the same proofs of a northward sink- for the Champlain period, in the region between the Upper ssippi and Lake Winnipeg. (See his Memoir on the Valley of linnesota.) He showed, by the facts, that Lake Winnipeg had had a very great expansion and then had discharged south- by Minnesota River valley; but that afterward, subsequent .e Glacial period, a change of level in the land had taken by a subsidence to the northward, or a subsidence that was vely greatest in that direction, which turned their course ;he present outlet toward Hudson's Bay.

addition, General Warren observed that the southward dis- ;e of Lake Winnipeg must have been determined by a previous rising of the land to the north (as referred to in a notice of his report in this Journal, vol. ix, p. 313); thus sustaining the idea of an elevation of the interior of the Continent at the opening of the Glacial period, and an elevation which was greatest to the north. These conclusions—an elevation increasing in amount northward, followed after the Glacial period by a subsidence increasing northward—were reached without reference to any preconceived hypothesis.

Sand-bars.—Gen. Warren also describes with detail the form and structure of the sand-bars in the Wisconsin River, giving facts that are of general geological interest. The surface of these bars has a gradual pitch up stream, and a steep front down stream—as in a ripple mark. The sands are dropped where there is still water along the shores, but the larger part in the still water on the down-stream edge of the bars, thus building up this edge toward the water's surface. The sand, where the current is strong, "is moved along the gentle slope of the upper side till the crest is reached, when it falls over and stops in the still water below." The bar thus grows and becomes more convex in its down-stream outline. Such sand-bars have a channel of deep water either side, and also tend to make, by acting as a dam at the low-water stage of the stream, large areas of deep still water above them. The changes in the current produced by the growth of the bars and the greater changes from change of level in the river by floods, produces frequent changes in the bars, so that they are not the same in position from year to year. At very low water, the bars may be mostly dry, with winding narrow channels of water among them. This tends to improve the navigation for the time; but a rise, if small and temporary, sends the water across these channels and fills them up.

The sand-bars made in the Mississippi by the discharge of the Wisconsin are of great extent. Besides pushing the deep water channel to the west shore, they act as a dam and make an area of relatively still water above, thus causing good navigation above the junction and bad below—a common fact at junctions in the rivers of the Mississippi basin. The Wisconsin River flows from a region of much less summer rain than the Mississippi, and is often at low-water stage when the latter is high; and hence it is made very shoal by sand-bars formed in its mouth.

The sands of the Wisconsin River bars are almost purely siliceous, and come from the drift deposits bordering its course. The specific gravity, "excluding voids," of two specimens from different parts was 2·6392 and 2·6667. For comparison the specific gravity of other sands was obtained, as follows: at St. Paul, Minnesota, on the Mississippi, 2·6397; at Rock Island, Illinois, 2·6166; at Saybrook Bar, mouth of Connecticut River, 2·6406; at Block Island, R. I., 2·6392; at Newport, R. I., 2·6563. The Report also compares different sands as to proportional fineness, giving the proportion that passed through sieves of different grades; and, also, as to the changes in volume in different sands due to wetting when loose and packed. The loose sands of the Wisconsin River shrink in volume ·0146, and ·0197 (two specimens); while that of Saint Paul shrinks ·0695; that of Block Island, R. I., ·0788, and that of Newport, R. I., ·1352. These investigations of different sands were made in order to ascertain the reason why the Wisconsin sands are " easily moved "

2. *Ice work now going on in Newfoundland.*—Mr. S. MILNE gives many valuable facts on modern ice-work in Newfoundland in a paper in the Geological Magazine for September last, from which the following are here cited.

Ice forms on the shores from the spray and occasional snows, enveloping and thus grasping firmly the stones and bowlders beneath, and attaining considerable thickness; and when a northern pack strikes it, it is pushed up shore, sometimes to a distance of a hundred yards. In the movement the rocky surfaces beneath are polished and scratched in a style precisely like the work of glaciers. The breaking away of the pack near the water line leaves the stranded ice with a thick front called by the fishermen a *balacada*, a corruption probably of *baracada* of the Spanish. This shore ice, with its cargo of bowlders, stones and gravel, is often drifted off as the tide rises, and especially when a land breeze favors; and great lines of bowlders off the shore are thus made. In the same way the cables and anchors left on the shore have sometimes been carried off,—to the regret of the fishermen.

The blows made by the coast-ice when driven up the land, or by the floating ice when pushed ashore, have immense power and do great execution on the rocky bluffs. Scoresby's calculation, that the blow produced by one of the immense ice-fields is equal to that of 10,000,000,000 tons, affords an idea of the force of the impact in many cases, and aids us in realizing the greatness of the work of coast degradation carried on in every cold season by the reiterated strokes.

3. *The Glaciation of the Shetland Isles.*—In the Geological Magazine for May and June, 1870, my colleague, Dr. Croll, first pointed out that the Scotch and Scandinavian ice-sheets probably united on the floor of the North Sea, and thence moved westward toward the Atlantic. He was led to this conclusion by a consideration of the peculiar direction of the striæ in Caithness, in Shetland, and the Faroe Isles, as well as by the occurrence of marine shells in the bowlder clay of the northern parts of Caithness. He showed that the enormous *mer de glace* which pressed out on all sides from Scandinavia forced its way close to the Scotch coast-line, and in virtue of its greater size produced a slight deflection of the Scotch ice, causing it to over-ride portions of the main land. He stated that in all likelihood both the Shetland and the Faroe Isles were over-topped by the Scandinavian ice in its onward march toward the Atlantic.

During a recent traverse in Shetland I obtained evidence which tends to strengthen this remarkable theory. In the north island of Unst, the direction of the striæ, the bowlders on the surface, and the stones in the till, clearly indicate that this island was glaciated by a mass of ice moving from east to west. The proofs of continental glaciation, which are comparatively clear in the north, are obscured in a great measure in the main island by the effects of a local ice-sheet. The nature of the bowlder clay, as well as the trend of the striæ in various localities, show that the movement of this local sheet was influenced by the general features of the country. In addition to these markings, however, others were found which could not have been produced by ice shedding off the land in the ordinary way. These cross the island, regardless of its physical features, and are often at right angles to the newer set. Lastly, the wide distribution of morainic matter with groups of moraines indicate the gradual disappearance of the local ice-sheet and the presence of small glaciers, where the ground presented favorable conditions for their development.

The islands are dotted over with small lochs; the most of these lie in peat or drift, while others occupy true rock basins. The singular absence of marine terraces ought not to escape notice, as bearing on the recent geological history of these islands, since the voes or sea-lochs are admirably adapted for their preservation.

These observations will be described in detail in a forthcoming paper before the Geological Society. JOHN HORNE. —*Nature*, Dec. 14, 1876.

4. *Note on the relations of Balanus Estrellanus of the California Miocene;* by T. A. CONRAD. (From a letter to J. D. Dana, dated Philadelphia, Dec. 4, 1876.)—Some time ago I wrote you for your opinion of the propriety of classing *Balanus Estrellanus* (*Tamiosoma gregaria*) with the *Rudistæ*. It seemed so strange to me, that a member of the *Rudistæ* should be in Miocene strata, that I have recently studied its characters anew, and find it to be a true *Balanus*, and I think you will agree with me, if you consult the figure and description of *B. lævis* figured in Darwin's Monograph, pl. 4, fig. 2. In that figure the basis exhibits septa of the precise character of *B. Estrellanus;* besides, the loss of the basis shows the same structure as other Balani, but the opercular valves are not preserved. Mr. Gabb fully agrees with my determination.

I have also had occasion to restrict the number of genera which were supposed to be common to Cretaceous and Eocene strata. Thus I eliminate the genus *Cucullæa* from the Cretaceous fauna, it being represented by *Idonearca.* I think also that *Trigonia* died out at the close of the Cretaceous; for, of the many species known, none had ribs radiating from the beak, like a *Cardium*, and being unknown in Eocene strata; when the allied genus appears in the Miocene and recent fauna it assumes the radiated structure. I also exclude from the Cretaceous fossils the following genera of Veneridæ: *Callista*, *Caryatus*, *Dione*, *Grateloupea*, *Cryptogramma*, *Circe*, *Dosenia*, *Mercenaria*, *Venus*, etc., retaining only *Aphrodina*, *Cyclothyris*, *Baroda*, and *Dosiniopsis*. Some genera, as *Cardium*, *Pecten*, *Radula*, *Ostrea*, *Anomia*, *Spondylus*, *Axinæa*, *Turritella*, etc., were continued from Cretaceous strata to he recent period, but I have not yet made out a list of all the extinct genera. As it is interesting to note the occurrence of corresponding extinct genera in America and India of the same Cretaceous horizon, I would remark that in Stoliczka's Paleontology of Southern India, figs. 1 to 5, pl. vi, represent the genus *Cyclothyris*, though referred to *Cyclameria* by Stoliczka; and figs. 17–19 (*Cytheria* Stol.) belong to *Aphrodina* Con. Both of these genera are common in North Carolina.

5. *Stromatopora.*—In the number of the Annals and Magazine of Natural History for January, *Stromatopora concentrica* is pronounced a Sponge in a paper on a new genus of Cretaceous Hexactinellid Sponges, by W. J. Sollas. A second paper, by H. J. Carter, treats of the close relationship of *Hydractinia*, *Parkeria*, and *Stromatopora*, thus making the genus, or part of it, Hydroid in its relations, and so removing it far from the Protozoans.

6. *Geological Survey of Victoria. Report of Progress*, by R. BROUGH SMYTH.—The most important Report in this volume is a long one on the Devonian rocks of North Gippsland, by A. W. Howitt.

7. *Fossil Elephant in Washington Territory;* by WM. O. MATZGER. (From a letter dated Daytown, Washington Territory, July 8, 1876.)—The bones include a pelvis, jaw bone, tusk, and others. The pelvis measures 5 feet 10 inches across its widest part, and the tusk is 10 feet long. The jaw bone is two feet wide, and has one tooth on a side, measuring at top ten inches by three. The discoverer thinks that he has found portions of at least five individuals.

8. *Mesozoic Fossils*, Vol. I; Geological Survey of Canada. Part I. *On some Invertebrates from the coal-bearing rocks of the Queen Charlotte Islands*, collected by J. RICHARDSON in 1872; by J. F. WHITEAVES. 92 pp. 8vo, with 10 plates of fossils, and a map.—The Queen Charlotte Islands lie just to the north of Vancouver Island. The fossils are in general too imperfect for satisfactory identification. They include a large proportion of species of the Ammonite family. They have some Oölitic affinities, while "at least one or two are known to be Cretaceous," and indicate a relation in the beds rather to the Shasta Group (Lower Cretaceous) of California and of British Columbia, than to the Cretaceous of Vancouver, or the Chico group of California. No Vancouver species is found among them. They may belong just below the Cretaceous. Out of the 42 species of Mollusks, three—*Ammonites Brewerii*, *A. Stoliczkanus* and *Aucella Piochii*, are well-known California Cretaceous fossils.

9. *Miocene in Southern New Guinea.*—Mr. C. S. WILKINSON, of the Geological Survey of New South Wales, after an examination of specimens obtained in New Guinea by William MacLeay, Esq., announces the occurrence of Calcareous clays and other beds from Hall's Sound, which are of the *Lower Miocene*,—a fact of much interest since no marine Tertiary beds have yet been reported from Eastern Australia, while they are found in Victoria

and South Australia. Professor M'Coy, as Mr. Wilkinson states, has shown that the Miocene fossils of Southern Australia were closely related generically, and even specifically to those of many parts of Europe and America. The New Guinea species are mostly identical with those of Victoria. They include *Voluta anti-cingulata*, species of *Ostrea*, *Cytherœa*, *Crarsatella*, *Pecten*, *Turritella*, *Astarte*, *Corbula*, *Leda*, *Venus*, *Cypræa*, and other genera. Mr. Wilkinson makes the following concluding observations:

The discovery of these Miocene beds on the southern coast of New Guinea is one of considerable importance. Their occurrence, I believe, suggests the former land-connection of New Guinea with the Australian continent, and this belief is further borne out by the fact of the shallowness of the intervening sea.

From geological data it is believed that this continent [Australia] has not been submerged to any great extent, since the Lower Pliocene period; and we know that it has risen a little since the Upper Pliocene epoch, at least in Victoria, for the lava flows of that age, now forming the Werribee Plains, were *submarine* flows. And Mr. Daintree, formerly government geologist of Queensland, shows, in his pamphlet on the Geology of Queensland, that little upheaval of this portion of Australia has taken place since the volcanic outbursts of a late Tertiary epoch. Now, it is in the Upper Pliocene or Pleistocene deposits [or Quaternary] that are found the remains of the gigantic marsupials—*Diprotodon*, *Macropus titan*, *Nototherium*, and others; and, as their allied representatives now occupy both Australia and New Guinea, it is not improbable that those gigantic animals, whose bones are found in Northern Queensland, also roamed in both those countries. And farther, as the luxuriant vegetation and climatic conditions which we suppose to be favorable for the support of those immense marsupials, still exist in New Guinea, is it rash to conjecture that some of these large creatures may not be living there at the present time? Farther researches may prove this.

10. *Recherches sur les Fossiles Paléozoiques de la Nouvelle Galles du Sud* (Australie); par L.-G. DE KONINCK, D.M. 140 pp. 8vo, with at atlas in 4to. Bruxelles. 1876. (Mem. Soc. Roy. des Sci. de Liege.)—This paper contains descriptions and figures of many Australian species, and of them a considerable number are identical with those of its antipodes, Europe and Britain, or of North America. Among the latter from Silurian beds, are *Halysites escharoides*, *Alveolites repens*, *Favosites cristata*, *F. Forbesi*, *F. aspera*, *F. fibrosa*, *F. Gothlandica*; *Chonetes striatella*, *Leptæna quinquecostata*, *L. compressa*, *Strophomena pecten*, *S. rhomboidalis*, *Pentamerus Knightii*, *P. oblongus*, *Orthis canaliculata*, *Atrypa reticularis*, *A. hemisphærica*, *Spirifer crispus*, *Meristella tumida*; *Pterinea ampliata*, *Orthoceras ibex*, *Cheirurus insignis*, *Encrinurus punctatus*, *Calymene Blumenbachii*, *Bronteus*

artschii, *Harpes ungula*, and others; and there are as many from 1e later Paleozoic. The author hence confirms the conclusion xpressed by McCoy, with regard to the general specific identity f the marine fauna of the two hemispheres in the Silurian age, nd extends it to all Paleozoic time, including the Carboniferous ge, so that we may say that "the entire marine Paleozoic fauna ras subjected to the same general influences." The species occur n many cases of larger size than in Europe or America. Prof. de Koninck states that he was mainly indebted for the specimens he as described to the Rev. W. B. Clarke, who has long worked in ustralian Geology.

11. *On the Syenitic mountains of Ditro, and the Trachytic, largitta, near Büdösch in Eastern Transylvania, with observa- ions on the Auriferous Districts of Vöröspatak and Nagyag*, y Prof. G. VOM RATH. 55 pp. 8vo. Bonn, 1876.—The Syenitic nountains of Ditro, described by Prof. vom Rath, extend from yergyo Szt. Miklos to Szarhegy and Ditro, having a length of wenty to twenty-one kilometers and a breadth of seven to eight. hey consist mainly of "nepheline-syenite" *miascyte*, and "soda- ite-syenite" or *ditroyte*. The former, which is the predominating ock, consists of a gray to greenish-gray nephelite (elæolite), white rthoclase and oligoclase, black hornblende with some biotite, ircon, sphene, magnetite, and pyrite, and is either coarse or fine rained. The elæolite is in grains and occasionally in masses two- hirds of an inch through. The miascyte graduates into the litroyte, or a rock containing blue sodalite and sometimes can- rinite and pyrochlore in addition to the ingredients of the mias- yte. The orthoclase of the ditroyte gave Prof. vom Rath the xygen ratio 1·018 : 3 : 11·438; and the blue sodalite was found y him to consist of

$\ddot{\mathrm{Si}}$ 38·66, $\overline{\overline{\mathrm{Al}}}$ 32·61, $\dot{\mathrm{Ca}}$ 0·95, $\dot{\mathrm{K}}$ 1·04, $\dot{\mathrm{Na}}$ 13·28, Na 3·93, $\dot{\mathrm{H}}$ 2·36, Cl 6·08.

n these mountains there is also a reddish quartzless syenyte-like ock, consisting of a reddish orthoclase, black biotite and horn- lende with some yellow sphene.

Prof. vom Rath describes in this paper also the trachytic rocks f the vicinity and their relations, giving analyses of the andesite r plagioclase feldspar; and then discusses the auriferous region nd rocks of Vöröspatak and the auriferous tellurium regions of Nagyag (pronounced Nadj-åk). In the Vöröspatak region, as ited from Grimm, the gold-bearing rocks are: (1) the Carpathian andstone referred to the Eocene containing beds of argillyte, and aving vertical ore-bearing veins; (2) a feldstone-porphyry, which s stated to be an eruptive rock, containing quartz in numerous nd large dihexahedral crystals; and (3) a "porphyritic sand- tone newer than the Carpathian, which is accompanied by a rystalline slate, and sometimes becomes a breccia, and is inter- ected by numerous small veins of quartz and pyrite.

12. "*Greenstones*" *of Western Cornwall;* J. ARTHUR PHILLIPS, Esq. (Q. J. Geol. Soc., May, 1876.)—This paper has special nterest on account of the various opinions with regard to the

relations of diorytes and other "greenstones." The rocks which it describes are greenish slates, greenish crystalline rocks without a trace of lamination, into which the slates pass by gradual or abrupt transitions, and also killas or clay-slate. The kinds of greenstone least metamorphic consist, as seen in thin sections under the microscope, of a plagioclase feldspar, augite or diallage, magnetic titanic iron, with occasional specks of pyrite, and also a little apatite, and with rarely flakes of brown mica, some hornblende, and a chlorite. The more altered kinds have a semi-transparent base, through which hornblende and the chlorite are thickly disseminated; and in it there are green pseudomorphs after augite, and faint outlines of feldspar crystals. In some places there are large crystals of the feldspar, yet with the augite changed to hornblende and chlorite. The material of the intersecting veins is the same, except that it contains a little more green hornblende. In other places the augite is but slightly altered, while the feldspar crystals appear merged in a colorless slightly opaque base, which shows faintly the outlines of the feldspar crystals.

Four different varieties of the greenstones afforded on analysis:

	I.	II.	III.	IV.
Silica	46·32	47·22	43·48	47·26
Alumina	18·18	19·85	18·60	21·64
Ferric oxide	0·82	1·01	3·68	3·97
Ferrous oxide	10·92	9·87	11·38	8·92
Manganous oxide	*trace*	*trace*	*trace*	*trace*
Magnesia	7·46	6·30	6·01	4·02
Lime	9·32	10·18	12·31	6·01
Potash	2·07	1·12	1·12	1·91
Soda	2·95	2·13	1·69	3·77
Phosphoric acid	0·52	0·95	*trace*	0·33
Water, hygrometric	0·24	0·21	0·22	0·29
combined	0·76	0·80	1·17	1·92
Pyrite	0·32	0·17	*trace*	*trace*
	99·88	99·81	99·66	100·04
Specific gravity	3·02	2·97	3·01	2·98

No. 1 is greenish and crystalline, and consists, as shown microscopically, mainly of augite and feldspar, the former predominating, with some chlorite, brown and green hornblende, and magnetite; and came from north of St. Peter's Vicarage in Tolcarn. No. 2, from Tolcarn Quarry, resembles No. 1, but is of lighter color, and consists of feldspar with altered augite, chlorite, magnetite partly replaced by a greenish-gray mineral, and apatite. No. 3, from Tolcarn Quarry, is very fine-grained crystalline, sage-green in color, and consists chiefly of hornblende and altered feldspar and chlorite, the augite being replaced by hornblende and chlorite. No. 4, from Chapel Rock ("which rests on slate"), is crystalline and greenish-gray, somewhat felsytic in appearance and consists of a feldspar base, with crystals of feldspar, hornblende in angular patches replacing augite, chlorite, apatite, magnetite.

With these rocks occur fine-grain crystalline slaty kinds, which graduate into killas or clay-slate. These slaty crystalline rocks are bluish-green to greenish-gray; and the slaty structure is sometimes wanting. They consist largely of hornblende in minute acicular crystals, with some chlorite, and not unfrequently a slightly opaque base, and with occasional patches of quartz, and sometimes magnetite. An average slaty kind of a dark color gave on analysis the results in column A below. A rock of grayer color, similarly hornblendic, containing much magnetite, afforded the results in column B.

	A	B	C	D
Silica	37·44	50·51	37·63	48·41
Alumina	16·32	19·69	17·15	17·02
Ferric oxide	7·33	1·28	7·53	2·68
Ferrous oxide	14·75	7·40	16·03	9·41
Manganous oxide	*trace*	*trace*	0·40	*trace*
Magnesia	6·06	8·04	3·52	6·20
Lime	12·83	7·38	13·95	13·15
Potash	1·50	1·00	0·94	0·30
Soda	1·85	3·41	0·95	2·13
Water, hygrometric	0·54	0·20	0·40	0·12
combined	0·77	0·63	1·07	0·65
Phosphoric acid	0·27	*trace*	0·46	*trace*
Pyrite	0·23	....	*trace*	*trace*
	88·89	99·67	100·03	100·07
Specific gravity	3·29	2·89	3·35	3·03

(A hornblende of Botallack, Cornwall, having sp. gr.=3·24, afforded A. G. Phillips—Silica 40·12, alumina 16·75, ferric oxide 4·32, ferrous oxide 12·70, manganous oxide 3·42, magnesia 6·82, lime 12·37, potash *trace*, soda 2·65=100·09.)

A compact greenstone, dark greenish black, and crystalline, from Pendower Cove, in Gurnard's Head District, largely made up of hornblende, with an occasional grain of quartz, afforded the composition in column C, above. Another greenstone, bluish gray and distinctly slaty, from two miles west of Camborne, having sp. gr. =3·03, and consisting largely of flakey hornblende as seen under the microscope, afforded the composition of column D. Another, from North Huel Rose, in Newlyn East, was grayish, and had a chert-like aspect, with a tendency to break into plates. The greenstone rocks in St. Ives District consist of hornblendic slates, interbedded with augitic rocks and occasional bands of clay-slate; those of the Cape Cornwall District are stratified, with usually a distinct slaty cleavage.

Mr. Phillips speaks of the greenstones as in part altered gabbro or doleryte; others as metamorphic hornblendic slates, some of them containing garnet, magnetite or axinite; others as killas or ordinary clay slates, containing usually much more silica than the greenstones; others as metamorphic and highly basic hornblendic rocks, having a tendency to break into thin plates.

From the facts connected with the "greenstones" of the western half of the New Haven region and of New Hampshire, it appears probable that even the rocks of dolerytic composition (the augitic kinds) are ordinary sediments metamorphosed, and constitute either *metadoleryte* or *metadiabase* according to the prevalence of chlorite or not; that part of the hornblendic kinds—those that contain the requisite feldspar—are basic *metadiorytes*, and that the latter pass into hornblendyte (hornblende rock), and also into labradorite-dioryte and anorthite-dioryte, other metamorphic rocks. J. D. D.

13. *Petrographische Studien an den Melaphyrgesteinen Böhmens*, von Dr. E. Boricky. Prag, 1876.—The volume in hand is a continuation of Dr. Boricky's valuable examination of the igneous rocks of Bohemia.

14. *Minerals of New South Wales*, by Prof. A. Liversidge. 63 pp. 8vo. Sydney, N. S. W. 1876.—Prof. Liversidge has given a complete and valuable list of the minerals of New South Wales, with descriptions mostly taken from specimens which he had himself had in hand. The occurrence of gold is described in detail, and an enumeration is given of some of the larger nuggets which have been found. The average chemical composition of the ore obtained is 93½ p. c. gold, and about 6 p. c. silver. E. S. D.

15. *The Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland;* No. 1, August. 1876, and No. 2, November, 1876.—The Mineralogical Society of Great Britain and Ireland was instituted February 3d, 1876, with special reference to the advancement of the Sciences of Mineralogy and Petrology. The officers of the Society are as follows: President, H. C. Sorby, Esq.; Vice Presidents, Rev. Professor Haughton and Professor Heddle; Treasurer, R. P. Greg, Esq.; General Secretary, J. H. Collins, Esq.; Foreign Secretary, C. Le Neve Foster, Esq. The first two numbers of the Society's Journal contain a number of interesting papers; among these are descriptions by Mr. J. H. Collins of the following new minerals:

Henwoodite. Occurs in globular masses of a turquois-blue or bluish-green color upon limonite; the exterior surface of the masses shows indistinct crystalline facets. H.=4–4·5, G.=2·67. Analysis: P_2O_5 48·94, $\text{Ⱥl}O_3$ 18·24, $\text{₣e}O_3$ 2·74, CuO 7·10, CaO 0·54, SiO_2 1·37, ign. 17·10, loss 3·97=100·00. It is somewhat related to lazulite, wavellite, and turquois, but differs in the relative amounts of alumina and phosphoric acid. Found at the West Phœnix Mine in Cornwall.

Enysite. Occurs in stalactitic forms in a cave at St. Agnes, Cornwall. H.=2-24, G.=1·59. Color bluish-green. B.B. infusible; in the closed tube yields much water. Analysis: SO_3 8·12, $\text{Ⱥl}O_3$ 29·85, CuO 16·91, CaO 1·35, SiO_2 3·40, H_2O 39·42, CO_2 1·05, Na_2O, Cl. $\text{₣e}O_3$ tr.=100·10. The mineral is regarded as one of comparatively recent origin. E. S. D.

16. *Prospectus of the "Zeitschrift für Krystallographie und Mineralogie," under the editorial charge of Prof. P. Groth, "unter Mitwirkung zahlreicher Fachgenossen des In- und Auslandes."*—In this prospectus Dr. Groth gives in full the plan and objects of his new Journal of Crystallography and Mineralogy,

the proposed publication of which has already been announced in this Journal (vol. xii, p. 152). The Zeitschrift will fill a place hitherto unoccupied by any scientific publication, being especially devoted to the science of Crystallography in its relation particularly to Mineralogy, and also to the departments of Chemical and Physical Mineralogy. It will thus cover the whole field of mineralogy. Moreover, in addition to original articles, it will contain abstracts of all mineralogical papers wherever they may appear, and in whatever language, and thus become a complete repertorium for the science. To carry out this part of the work, certainly not the least important, the editor has secured the coöperation of leading active mineralogists in England, America, Italy, Denmark, Norway, Russia, Hungary, Bohemia, etc. It is hence evident that the Zeitschrift will be a most invaluable help to all workers in this field of science; and it is much to be hoped that the distinguished and energetic editor will find the hearty support which he deserves, not only in Germany, but in all countries where the science is cultivated. It will be published in octavo numbers of 6 to 7 signatures, commencing with January, 1877. Each volume will include six numbers, and, with the accompanying plates, will cost not more than 30 marks. Authors of original articles will receive free twenty-five extra copies. The publisher is W. Engelmann in Leipzig.

III. BOTANY AND ZOOLOGY.

1. *Ulothrix zonata. Ihre geschlechtliche und ungeschlechtliche Fortpflanzung;* Dr. ARNOLD DODEL.—This paper, which fills the greater portion of the fourth part of the tenth volume of Pringsheim's Jahrbücher, is an important contribution to our knowledge of sexuality in plants in its simplest phase. In spite of the methodical arrangement of the article, it is elaborated with such excessive minuteness, accompanied occasionally by somewhat futile speculation, that it is by no means an easy task to read it. This is to be regretted, as many of the facts brought forward are quite curious. The genus *Ulothrix* belongs to the order *Zoösporeæ* in which the reproduction takes place by means of macrozoöspores and microzoöspores, the former having four cilia and one germinative spot (the name given to the reddish-colored dot found on one side), the latter having only two. The former bodies have for some time been considered non-sexual, while the latter have been supposed to represent sexual organs which by their union form a body with four cilia, and distinguished from the macrozoöspores by having two germinative spots instead of one. This body, which is called the zygospore, corresponds to the organ of the same name in the *Desmideæ* and *Conjugatæ* proper. Dodel confirms the views of Areschoug, Cramer and others, that the macrozoöspores do not conjugate, but, after losing their cilia and coming to rest, grow at once into a new plant. He also agrees, in the main, with Areschoug as to the conjugation of the microzoöspores, and besides has been able to give a more exact account

of what becomes of the zygospores. He finds that they remain for a considerable time unchanged, and finally divide into a number of zoöspores, which soon come to rest and grow into new plants, as in the case of the macrozoöspores. The latter it appears are more common in winter and spring, and were produced abundantly on thawing tufts which had been frozen, while the microzoöspores are more common in summer.

The most curious fact observed by Dodel is that those microzoöspores which, for any reason, do not succeed in conjugating, grow at once into new plants just as in the case of the macrozoöspores. In other words, the sexual process is reduced to the direct union of two bodies so similar that it is impossible to distinguish one as male and the other as female, and furthermore these bodies, if not placed in conditions favorable for conjugating, can at once grow into new plants. It would be difficult to find sexuality of a lower grade than this, where each sexual organ is also capable of reproducing the plant by non-sexual growth. We would recall the case of *Eurotium herbariorum* mentioned by De Bary, where, of the several male organs (pollinodia) only one succeeds in coming in contact with the female organ, yet all, after the fertilization has taken place, continue to grow and take part in the formation of the sac which eventually encloses the spores. With very rare exceptions in the Thallogens, the male organ at once atrophies after fertilization has been accomplished.

W. G. F.

2. *De Copulatione Microzoosporarum Enteromorphæ compressæ*, (L.) Scripsit J. E. Areschoug, ex Botaniska Notiser. 1876. No. 5.—In their Observations sur quelques algues possédant des zoospores dimorphes, Janczewski and Rostafinski called in question the observations of Areschoug in which he maintained that the microzoöspores of *Enteromorpha compressa* conjugated. In the present paper Areschoug gives a detailed account of repeated observations of the conjugation of microzoöspores of *Enteromorpha compressa* made during the past summer, and it would appear that Janczewski and Rostafinski had been too hasty in their criticisms. Areschoug mentions that Wittrock has found zygospores in *Hæmatococcus lacustris* (*Protococcus nivalis*) the existence of which Rostafinski denied. W. G. F.

3. *Professor Sir Wyville Thomson on some of the Echinoderms of the "Porcupine" and "Challenger" Expeditions.*—One of the recent numbers of the Transactions of the Royal Society of London contains an account by Professor Thomson of the Echini of the "Porcupine." The most interesting portion is a full description with excellent figures of several species of the new family of Echini with flexible test, intermediate between the Cidaridæ and Diadematidæ, the genera *Thermosoma*, *Calveria* and *Asthenosoma* constituting the family. The structure of the Echinothuriæ, as this family has been called by Sir Wyville, throws a good deal of light on the affinities of the extinct Palæechinidæ.

In addition to the Crinoids noticed by Professor Thomson in one of his former preliminary reports addressed to the Royal Society, he has published a short account of two remarkable genera belonging to the family of Apiocrinidæ, which are described as *Bathycrinus* and *Hyocrinus*, the former from a depth of 2475 fathoms, south of Cape Clear, the latter from a depth of 1850 fathoms, 300 miles east of St. Paul's Rocks. The paper is illustrated by five cuts, and forms the beginning of No. 66 of the Journal of the Linnean Society for December, 1876. *Bathycrinus* is allied to *Rhizocrinus*, while *Hyocrinus* has a superficial resemblance to *Poteriocrinus* and *Cyathocrinus*. In the same number of the Journal of the Linnean Society, Sir Wyville Thomson has given a most interesting account of the direct mode of propagation in a number of Echinoderms, showing that this mode of reproduction is not so exceptional among Echinoderms as was formerly supposed. The direct mode of reproduction was already known in all the orders of Echinoderms (Holothurians, Ophiurans, Starfishes, Echini and Crinoids). It had however been supposed that the plutean development was the normal mode of reproduction among Echinoderms, although the complete homology between the direct and plutean embryology has been pointed out by several writers on the Echinoderms. The sketch referred to shows most conclusively that this view was correct and opens a most interesting field of speculation regarding the causes which may have brought about, often in closely allied genera, one or the other mode of reproduction. It is somewhat curious that the majority of cases of direct reproduction are of species found in the northern regions of the old world, the species observed by Professor Thomson are all from the Southern Sea; Falkland Islands (*Cladodactyla crocea* Lessen, *Goniocidaris canaliculata* A. Ag.); Heard Island (*Prolus ephipper*); Kerguelen Isls. (*Cidaris nutrix* W. T., *Hemiaster*, sp. *Archaster excavatus* W. T., *Hymenaster*, and *Ophiocoma didelphys* W. T. These species are all figured with the young as they are carried about by the parent. A. AG.

4. *Zoology of the Challenger Expedition.*—The editors learn by letter from Mr. ALEXANDER AGASSIZ (dated Edinburgh, Dec. 18) that he has found the material a wonderful collection, and was deeply impressed by the great amount of it, coming as it mainly does from the depths with which we formerly associated the idea of a lifeless desert region. He also gives the following information respecting the publication of the results. "The Admiralty is to publish the results and the collections are to be worked up by sundry specialists: Allman the Hydrozoa; Busk the Polyzoa; Dr. McIntosh the Annelids; Thomson himself the Crinoids and some of the Sponges, the balance of the latter by O. Schmidt; Hæckel the Radiolaria; Moseley of the Challanger the Polyps; Murray who was on the Challenger will work up the deep sea bottoms and surface animals (Foraminifera, etc.); Günther the Fishes. Some of the groups are not yet determined upon, but the same persons who worked up the "Porcupine" species will probably have charge

of the Challenger collection. Young Carpenter will work up the Comatulæ, Lyman will have the Ophiurans, and I shall bring over with me the Echini and perhaps some other group of Echinoderms, so that the United States will have their fair share of the work."

5. *Rate of Growth of Corals.*—A remarkable piece of coral, taken off the submarine cable near Port Darwin, is spoken of by the Cocktown Herald. It is of the ordinary species, about five inches in height, six inches in diameter at the top, and about two inches at the base. It is perfectly formed, and the base bears the distinct impression of the cable, and a few fibers of the coir rope used as a sheath for the telegraphic wire still adhering to it. As the cable has been laid only four years it is evident that this specimen must have grown to its present height in that time, which seems to prove that the growth of coral is much more rapid than has been supposed.—*Melbourne paper.*

7. *Bulletin of the Nuttall Ornithological Club.* Editor, J. A. ALLEN; Associate Editors, S. F. BAIRD and ELLIOTT COUES.—The November number closed the first volume of this excellent journal. It contains papers by E. Ingersoll, Dr. J. G. Cooper, R. Ridgeway, J. C. Merrill, M.D., U.S.A., and T. M. Brewer, besides notices of recent publications and various miscellaneous notices.

The Journal has the best of American Ornithologists among its contributors, and is afforded at the low rate of one dollar a year (postage included). All interested in Birds, or in the progress of science, will find the small sum asked for subscription a good outlay. The prospectus states that, for the sake of sustaining the Journal, an advertising sheet will be inserted, and low rates of advertisement charged. Subscriptions should be forwarded to Mr. H. B. Bailey, Newton, Mass., and communications or advertisements to Mr. J. A. Allen, Museum of Comparative Zoology, Cambridge, Mass.

IV. ASTRONOMY.

1. *Meteor of Dec. 21st,* 1876.—On the evening of Thursday, Dec. 21st, 1876, a meteor of unusual size and brilliancy passed over the States of Kansas, Missouri, Illinois, Indiana, and Ohio. In many respects it is worthy of special record. From newspaper notices that we have been able to collect, from a few private letters, and from some letters kindly sent us by Prof. Henry, from the Smithsonian Institution, we are able to give a general account of the body.

It was first seen, so far as we know, over the State of Kansas, and probably as far west as the center of the State. It passed nearly over and probably south of the cities of Topeka and Leavenworth, being there at an altitude of about 60 miles. It crossed the Mississippi between Hannibal and Keokuk, but nearer to the former place. Over the center of the State of Missouri one or more explosions occurred, and shortly after crossing the Mississippi it broke into several fragments. The breaking up continued while it was crossing the States of Illinois, Indiana and Ohio. A loud explosion is reported as far east as Concord and Erie, Pa. The meteor consisted in fact of a large flock of brilliant balls chasing each other across the sky, the number being variously estimated from a score to a hundred. This flight is of peculiar interest in view of the long continued violent disintegration.

The region around Chicago was overcast, and though the clouds were lighted up in a most remarkable manner no sound seems to have been heard. In like manner no sound is reported from St. Louis. But over all the region of Central Illinois between these two cities a terrific series of explosions were heard. In Keokuk, Ia., it was heard, but not elsewhere in that State so far as appears from these accounts. A rumbling is reported as far south of the track as Bloomington, Ind., 120 miles distant, but whether it was caused by the meteor is doubtful. Yet over the northern part of Indiana the passage of the body was followed by loud explosions.

Whether a portion of the body pursued its way onward over New York State and out of the atmosphere is from the statements before us doubtful. The path was nearly parallel to the earth's surface and might easily be in its latter part upward. But if the sky was then clear over western New York the meteor would in such case certainly have been seen in that region.

The path was about N. 75° E., and was nearly or quite a straight line and not less than 1,000 miles long. The duration of flight was of course variously estimated, from fifteen seconds up to three minutes, and yet no one probably saw the body through more than a fraction of its path.

It entered the air in a course differing only about 30° from the earth's motion and was overtaking the earth. Its real motion made therefore a still smaller angle with that of the earth. But the relative velocity was so slow, probably not over ten or fifteen miles a second, that the earth's attraction had changed its direction greatly. It must have been coming, previous to that change, from a point near to and a little south of the ecliptic in the eastern or southern part of the constellation Capricornus. There appears to be no known meteor-radiant at that time near that part of the heavens.

Should no one else undertake the complete discussion of this meteor, we may treat it more fully in a future number of the Journal. We shall be grateful for any accounts of observers—especially of those who made angular measurements—whether we shall use them ourselves or place them in the hands of others for reduction. H. A. N.

V. Miscellaneous Scientific Intelligence.

1. *Bressa Prize, of the Turin Academy of Sciences.*—The fund for the Bressa prize—instituted by the bequest of M. César Alexandre Bressa, Doctor of Medicine and Surgery, who died in 1835—became available in 1876. A prospectus issued by the Royal Academy announces that, in carrying out the will of the testator, a prize, amounting to the income of two years, will be given in 1879, and every four years thereafter, to the man of science, *of*

whatever country, who shall, in the judgment of the Academy, have made, during the preceding four years, the most brilliant and useful discovery, or shall have published the most celebrated work, in pure or applied mathematics, or in the physical sciences, such as physics, chemistry, physiology, natural history, or in geology. pathology, history, geography or statistics; and, secondly, the same amount, on the same conditions, in 1881, and every four years thereafter, to an Italian savant. The prize will not be given to any of the National members of the Academy, resident or non-resident. The amount of the prize given in 1879 will be 12,000 francs.

2. *Annual Report of the Board of Regents of the Smithsonian Institution for* 1875.—The work of the Smithsonian Institution covers a wide range of subjects of both economical and scientific importance, and has a powerful influence for good on the welfare and scientific progress of the nation. As one example we cite the fact, stated in this report, that the department of the Institution having charge of fish-culture, which is under the direction of Professor Baird, distributed in the years 1874, 1875, of young shad, 18,689,550; of Penobscot salmon, 2,294,565; of California salmon, 4,581,340; making in all over twenty-five and a half millions which, with the distribution during the winter and spring of 1875–6, of these and other fishes, make a total of forty million fish supplied by the Commission in three years. The Report on the Museum shows great increase. One object of special interest acquired during the year, is the Tuczon meteorite, presented by Dr. B. J. D. Irwin, U. S. A. The very extensive collections displayed by the Smithsonian Institution at the International Exposition at Philadelphia were second in interest to none there exhibited. Very much of the credit connected with it is due to Dr. S. F. Baird, the assistant secretary of the Institution, who gives in this volume a statement of the general scheme of arrangements.

The general appendix to the Report contains the following papers,—Eulogy of Volta, by ARAGO; The probable future of the Human race, by A. DE CANDOLLE; Report on the Transactions of the Society of Physics and Natural History of Geneva, 1873 to July, 1874; The "Past and Future of Geology," by JOSEPH PRESTWICH; Report of the Special Committee for the Consideration of the Memoir of H. G. Wex on the diminution of the water of rivers; The refraction of Sound, by WM. B. TAYLOR; On the organization of local Scientific Societies, by Professor HENRY; On Ethnology: International Code of Symbols for Charts of Pre-historic Archæology, translated by O. T. Mason; Characteristics of Ancient Man in Michigan, by H. GILMAN; The Stone Age in New Jersey, by Dr. C. C. ABBOTT. The Ethnological papers are illustrated by a large number of figures of stone implements, skulls, etc.

3. *The Theory of Sound in its relation to Music*; by Professor PIETRO BLASERNA, of the Royal University of Rome. 188 pp. 12mo, with numerous woodcuts. New York, 1876. (D. Appleton & Co.)—This is a popular work in style by one who is deeply versed in the science of the subject of which it treats, and knows how to present its principles and facts briefly and clearly.

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[THIRD SERIES.]

IN MEMORIAM.—FIELDING BRADFORD MEEK.

THE readers of this Journal were informed in the January number of the death of Mr. F. B. Meek, the eminent Paleontologist. He died at Washington, D. C., on the 21st of December, 1876, having only a few days before completed his 59th year. He had been in ill health for several years past, and indeed almost all his life, for his malady was inherited *phthisis pulmonalis.* It had been his habit for several years, to spend the winter in Florida, and the summer months in the Alleghany Mountains. He had made preparation to leave Washington for Florida early in December, but was taken with hemorrhage of the lungs on the day before the one set for his departure. From this attack he never rallied, but gradually sank to a peaceful and quiet death. During his last sickness he was constantly attended and cared for by his scientific and other friends, resident in the city; and when the end came, they bore him to his grave with sincere sorrow.

Mr. Meek was born in the city of Madison, Indiana, on December 10th, 1817. His grand parents were Irish Presbyterians, who removed from the county Armagh to this country about the year 1768, and finally settled in Hamilton county, Ohio. His father, together with his family, removed from there to Madison, where he was a lawyer of considerable eminence. The family, including those born in Madison, consisted of the parents, two sons and two daughters, besides Fielding, all of whom were dead several years before his own decease. The father died when the son who was to become so distinguished was only three years old, leaving the family in moderate circumstances.

His early youth was spent in the city of his birth. His education was greatly interfered with by the delicate condition of his health. Upon reaching manhood, by advice of his friends and against his own inclination, for he was of a studious and retiring disposition, he invested his small patrimony in mercantile business, first in his native place, and afterward in Owensboro, Kentucky. The result was financial failure and loss of all he possessed. After this, while laboring for his support and struggling with ill health and poverty, he continued his studies, general and special, for he began early to devote himself to natural history. His first public work was during the years 1848 and 1849, and was performed as an assistant of Dr. D. D. Owen, upon the United States Geological Survey of Iowa, Wisconsin and Minnesota.

Having closed this work, he returned to his home in Owensboro; but soon after, in the year 1852, went to Albany, New York, as assistant to Professor Hall in the paleontological work of that State. He remained there until 1858, saving three summers. Two of these summers were spent on the Geological survey of Missouri; the other, that of 1853, in exploring the Bad-lands of Nebraska, together with Dr. F. V. Hayden, both being commissioned by Professor Hall for that work. Three years after this exploration, he prepared for publication, in conjunction with Professor Hall, an important memoir on Cretaceous fossils from Nebraska. This was published, with illustrations, in 1856, in the Memoirs of the American Academy of Arts and Sciences, of Boston.

In 1858, Mr. Meek left Albany and took up his residence in Washington, where he resided until his death. During all this time, he made his home, and the place of his scientific labors, except when in the field, at the Smithsonian Institution, and it was within its halls that the greatest part of his scientific life-work was accomplished.

The association which he formed with Dr. Hayden in 1853, was tacitly continued until Mr. Meek's death. When Dr. Hayden commenced his explorations in the Western Territories, and afterward organized the Geological Survey of the Rocky Mountain region, Mr. Meek was entrusted with all the Invertebrate paleontology, much of which appeared under their joint names. The most important of these joint publications was the "Paleontology of the Upper Missouri," published by the Smithsonian Institution in 1865, and admitted by all to have been the most thorough and exhaustive work of the kind that had been produced in the United States. During the continuance of this connection with Dr. Hayden, Mr. Meek accomplished many other very important works. Among the more noteworthy of these are, the invertebrate paleontology of the

Illinois State Geological Survey (published jointly with the Director, Mr. A. H. Worthen); that of the Ohio State Geological Survey; a part of that of the California Survey; that of several of the western exploring expeditions, besides those of Dr. Hayden's surveys of the Territories.

It was the custom of Mr. Meek to publish preliminary descriptions of his new species, and afterward elaborate and illustrate the subjects for final publication. These preliminary papers were published mainly in the Proceedings of the Philadelphia Academy of Natural Science, while his reviews, and memoirs on the higher groups were largely published in this Journal.

Only a few months before his death Mr. Meek finished what he considered to be the most important of work his life, namely: A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country. This work constitutes volume IX of the quarto series, of the U. S. Geological Survey of the Territories, and contains more than 600 pages of text, and 45 plates.

Of the character of Mr. Meek's scientific labors, it is only necessary to speak briefly. Thoroughness, scrupulous exactness, and nice powers of discrimination, are manifested in all his labors; and, with such merits, his works will shed lustre upon his name as long as paleontology shall be studied. No one in America has done more than he, to systematize and advance the science to which he devoted his life.

His personal character cannot be too highly eulogized, for it was without a blemish. He was a genial, sincere, pure-minded, honorable man. Gentleness and candor were apparent in every expression of his face, and in every word he uttered; but he was self-reliant, and ready at all times to stand up and defend what he believed to be right; and with his keen sense of justice, he was seldom mistaken as to what was right. He was never in vigorous health and often ill; but never complaining, always hopeful, always cheerful, always at the work he loved so well, always helpful of others. His hearing began to fail in early manhood, and the affliction increased until he became entirely deaf, several years before he died. Even when cut off from conversation with his fellow men his cheerfulness did not forsake him; but he seemed to derive great pleasure from written communication with his friends. He was never married, and leaves no near relatives; but all with whom he was ever brought in contact will remember him with pleasure, while to those who were permitted to enjoy scientific intercourse or correspondence with him during his life, his memory will be especially dear.

C. A. W.

ART. XX.—*Notes on the Age of the Rocky Mountains in Colorado;* by A. C. PEALE, M.D.

IN the "Report upon Geographical Explorations and Surveys west of the 100th Meridian, in charge of Lieut. Geo. M. Wheeler, vol. iii, Geology," Prof. John J. Stevenson, on the "Structure and age of the Rocky Mountain System," in Chapter XVII of his report, makes the following statement (p. 501): "The Rocky Mountain system, then, is the result of four especially marked upheavals, the first at the close of the Carboniferous, the second at the close of the Trias, the third at the close of the Cretaceous, and the fourth during the Tertiary. Of these, the first and third were the most general in their effects."

These conclusions he deduces from his investigations during the season of 1873, in the "area embraced between the meridians of 105° and 107° west from Greenwich, and between the north latitude 39° 45′ and the southern boundary of Colorado, giving a length of one hundred and ninety miles, and a breadth of about one hundred and six." (p. 307.)

My duties, as one of the Assistants of Dr. Hayden's Geological Survey of the Territories, have taken me over the same area, and as far west as the meridian of 109° 40′. From my study of this region, and the results of the work of my colleagues on the Survey, I am led to conclusions differing from those reached by Prof. Stevenson in regard to the age of the Rocky Mountains in Colorado. The data obtained are, however, too few to enable us to extend the generalizations to the *entire* Rocky Mountain system.

The first statement of Prof. Stevenson that I shall consider is the following. "The first great epoch of accelerated disturbance in the Rocky Mountain region, resulting in permanent elevation of the surface, was synchronous with that during which the Appalachian chain was completed." (pp. 499, 500.)

He bases this statement upon the following facts (?):

1st. The occurrence of Paleozoic strata high up on the flanks of the mountains and the absence of the Trias in the interior, and the abutting of the Cretaceous against the Paleozoic, (with the exception of the Elk Mountains.) p. 499.

2d. The want of conformability between the Paleozoic rocks and the Mesozoic rocks. (p. 499.)

I will take these up in order:

1st. *The occurrence of Paleozoic strata and the absence of the Trias in the Interior.* I use the name Triassic to denote the Red Beds that have been so called generally in the west. It is so used by Prof. Stevenson. Prof. Stevenson says, (p. 499): "In the interior* no rock of more recent origin than the Carboniferous is involved in the main axes." Again he says, (p. 495): "In the main portion of this second group (including Blue River Range, Park Range, Sangre de Cristo and Spanish Range, and Arkansas or Saguache (*Sawatch*) Range, see pp. 490, 491,) no rocks occur of later date than the Carboniferous, which with the underlying Silurian may be traced along the eastern face to the Blue River."

On the west side of South Park, the sedimentary formations† are present from the Primordial to the top of the Cretaceous, all conformable and dipping to the eastward, extending from the summit of the Park Range eastward into South Park. I grant that on the summit and slopes of the Range, the entire series is not seen, but simply because the range has been subjected to erosion. At some places only Silurian beds are seen and at others both Silurian and Carboniferous. Commencing at the summit of the range and going eastward into the Park, we find, with the exception of faulting in the Carboniferous and Silurian strata, which probably occurred in Post Cretaceous time that the formations succeed each other in regular order. The sequence is uninterrupted. It is true that when we compare the dip of the Carboniferous rocks on the range, with the dip of the Cretaceous out in the park, that it is not precisely the same, but we must remember that the outcrops are three or four miles apart. The inclination in both cases is in the same direction, and if the Cretaceous beds were continued to the summit of the Range as they did originally, we should find them conformable to the Carboniferous; and were we to sink a shaft at the base of the Cretaceous outcrop in the Park, we should doubtless note the conformability of the Cretaceous with the underlying Paleozoic strata. When we cross the upturned edges of the strata we find no uncomformability.‡

Crossing the Park Range to the Arkansas Valley, we find no sedimentary beds on the eastern front of the Sawatch Range. As pointed out by Dr. Hayden § and myself ‖ in 1873, the sedimentaries of the Park Range once extended uninterruptedly to the Sawatch Range, but have been removed by erosion. Prof. Stevenson is himself of the same opinion. He says (p. 492): "It is clear then that the Paleozoic rocks, the same with those found on the Park Range, at one time reached unbroken from South Park to the Arkansas or Saguache (*Sawatch*) Range. How terrible was the erosion which not only cut away these rocks but also tore out and removed the metamorphic rocks to a depth of 6,000 feet along this valley of the Arkansas."

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* He does not explain what he means by the interior, but I take it to mean the interior of his district.

† Wherever I speak of the entire sedimentary series I mean the sedimentary series as known in the West.

‡ See Report of U. S. Geol. Survey for 1873, pp. 38–47, pp. 212–239.

§ Report U. S. Geol. Survey, 1873, p. 39. ‖ Ibid., p. 246.

He restricts the sedimentaries to the Paleozoic. Why could not this erosion have removed not only the Paleozoic but also the Mesozoic strata? When we go to the north end of the Sawatch Range we find the entire series, from Lower Silurian to Upper Cretaceous, present. It is true that the lower strata project beyond the upper, the latter having been removed by erosion. Starting at one of the Archæan peaks at the northern end of the range and going northward, we meet first with a bed of quartzite, probably Primordial. This forms the capping of the spur, and at Eagle River disappears from sight beneath the beds forming the bluffs on the north side of the river. In the upper portion of these beds which are conformable to the quartzite, I obtained, in 1873, Carboniferous and Permian fossils.* Following the outcrops down Eagle River, we find appearing, one after the other, the other members of the series, Trias, Jura and Cretaceous, resting on the Carboniferous in regular order and conformable.† On the west side of the Sawatch Range the entire series is again seen towards the north.‡ The lines of outcrop can be traced from Eagle River to the Elk Mountains. Between the Elk Mountains and the Sawatch Range there is a gap occupied by the Upper Gunnison, or Taylor River, in which the Sedimentaries are absent. Were it not for the Elk Range, in which we have the result of eruptive action, the sedimentary rocks would be seen dipping away from the Sawatch Range to the westward and becoming horizontal in the plateau region.§

The upheaval of this range, with the subsequent erosion, has so modified the beds and removed so much material, that it is difficult at first sight to understand the relations of the sedimentary series to the metamorphics of the Sawatch Range. We must always make allowances for enormous erosion in this region. There are evidences of it on all sides in the Sawatch and Elk Mountains.

In Southwestern Colorado and Northern New Mexico, the Triassic is also present. (See Report of Macomb, Geology, by Newberry: also Cope, pp. 981–1017, Report of Chief of Engineers, Part II, for 1875.) Mr. Holmes and myself have also identified the Red Beds in Western and Southwestern Colorado, and in the forthcoming Reports of the Survey they will be described.

I think I have shown that the Red Beds (Triassic) are present not only in the interior but also west of the mountains, and that where the Paleozoic rocks alone show, the overlying rocks have been removed by erosion.

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* Report U. S. Geol. Survey, 1873, p. 245.

† Report U. S. Geol. Survey, 1874, pp. 79–84.

‡ Report U. S. Geol. Survey, 1873, pp. 245, 266. Report for 1874, p. 80.

§ Report U. S. Geol. Survey, 1874, p. 54.

2d. *The want of conformability between the Paleozoic Rocks and the Mesozoic Rocks.* I have already noted the conformability of the Paleozoic and Mesozoic in the Park Range, and on the north and west sides of the Sawatch Range. Prof. Stevenson (pp. 386, 497, 499, 500) notes unconformability between Mesozoic and Paleozoic along the Eastern Range, (*Front or Colorado Range,*) on the interior axes of elevation, and in the southern part of his area, in the San Juan Mountains, and near Tierra Amarilla, New Mexico. Speaking of the Front Range, he says: "Along the Eastern Range no Carboniferous rocks were exposed at any locality visited by me, but they have been seen elsewhere by others. They must be quite unconformable to the Trias, as it overlaps them very greatly." Along the Front Range the Carboniferous shows only where the overlying Triassic has been eroded away, and whatever unconformability there is, is an unconformability of subsidence and not of upheaval. The difference of dip between the Paleozoic strata and overlying Mesozoic is caused by an abrupt fold and the erosion of portions of the strata. Prof. Stevenson does not seem to remember that as we recede from the axis of elevation the dip of the rocks diminishes, and that if the more steeply inclined portion of the Mesozoic rocks be removed, as we recede from the mountains we meet only with the edges of the strata where they are becoming horizontal, and that the older layers below also flatten out in the same manner. I have already shown the conformability in the interior.

In the reports of Dr. Newberry* and Prof. Cope,† I can find no evidences of the unconformability in the southern portion of the San Juan Mountains and about Tierra Amarilla.

Dr. Endlich says‡ that in his district, "although the Cretaceous beds dip off, apparently uniformly, in the same direction (*with Carboniferous*) unconformabilities were noticed in several instances." These he thinks were due to a gradual rising of that portion which was then land. I am inclined to explain it by the subsidence which, as I hope to show farther on, occurred over so large a portion of what is now Colorado.

The next statement of Prof. Stevenson that I shall consider is, that "The second epoch of elevation began toward the close of the Triassic." (p. 500.)

This he bases on the unconformability between the Trias and the Cretaceous, which he observed along the Eastern Range at

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* In Macomb's Report on the Exploring Expedition to the junction of Grand and Green Rivers.

† In Report of Chief of Engineers, Part II, 1875.

‡ Report U. S. Geol. Survey, 1874, p. 215.

Golden, near Colorado Springs, and near Cañon City (pp. 490, 500), and also in Huerfano Park. Near Colorado Springs we have the following section.* Resting on the Archæan rocks are Silurian and Carboniferous rocks dipping eastward about 10°. Going eastward we next meet with Triassic red sandstones, standing on edge, or inclined past the vertical. From the Trias to the Dakota group of the Cretaceous the dip decreases to 40°, and this gradually diminishes eastward until at Monument Creek it is only 4°. At first sight there would appear to be unconformability, especially close to the Mountains, but the beds are conformable, and the varied dips show the presence of an abrupt fold, which is somewhat obscured by the subsequent erosion.† The same thing occurs near Golden, (see section 13 on plate opp. p. 136, Report U. S. Geol. Survey, 1873.) Mr. Marvine says,‡ "Within exceedingly short distances, then, great changes of dip may occur, and from them, with but slight changes of exposure, unconformability might be inferred. Yet all are perfectly conformable; the sudden change really indicating only a very abrupt flexure in the main fold, as indicated by the dotted lines." Near Cañon City, neither Dr. Hayden, Dr. Endlich, Mr. Holmes, nor myself have noted any unconformability. The other cases are probably similar to those of Golden and Colorado Springs.

What I now wish to show is that in Colorado the evidence exists that there was a subsidence commencing in, or prior to the Carboniferous, and continuing through the Triassic, Jurassic, Cretaceous and into the Tertiary. This may have been, and doubtless was interrupted by oscillations, but the general movement was depression until the close of the Cretaceous, when there were probably local elevations. A general gradual elevation of the whole West is not incompatible with local depression in Colorado. There are evidences that the upward movement began in Cretaceous time, but as pointed out by Dr. Hayden and Dr. Newberry the elevation of the Rocky Mountains took place between the close of the Cretaceous and that of the Miocene Tertiary.

From a study of the Carboniferous rocks in Colorado, we learn that during the earlier part of the Carboniferous age deep seas prevailed with large continental areas or islands. As the time progressed the seas became shallower and encroached more and more upon the land, which was composed mainly of Archæan rocks.

The Coal-measure rocks at the northern end of the Sawatch Range denote in their structure, the proximity of land during their deposition. They also show that they were derived from the degradation of Archæan rocks.* West of the Rio Dolores, in 1875 and 1876, I noted Upper Carboniferous rocks resting on the Archæan, and in the lowest bed, which was a coarse conglomerate, I noted large angular fragments of granitic rock exactly like that upon which the bed rested. Ascending, I noticed the beds becoming finer, showing that the shore line had advanced to the eastward. Farther east the red beds (Trias) rest on the Archæan for at least 20 miles (the length of the Unaweep Cañon) and probably more, with no older sedimentaries between them.

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* Report of U. S. Geol. Survey, 1873, pp. 201–205.
† See sections opp. p. 40, Report of U. S. Geol. Survey, 1874.
‡ Report of U. S. Geol. Survey, 1873, p. 136.

In New Mexico, Dr. Newberry found the Carboniferous rocks resting on the granite, with evidences of terrestrial surfaces near by when they were formed.†

It is evident therefore that there was Archæan land above the level of the Carboniferous sea, and that it was subsiding as the age progressed.

This subsidence continued through Mesozoic time. Along the eastern front of the Colorado or Front Range, with one or two exceptions where they have been removed by erosion, the Red Beds (Trias) rest upon the granite, (see Reports of 1873.) At the base of the series, Mr. Marvine found conglomerates of which he says, "It is in these lower parts, indeed, that the beds are so directly made up of the material of older rocks near by that a very little metamorphism has in some instances made it difficult to distinguish small masses of sandstone from the underlying granites."‡ In my own district, south of Mr. Marvine's, I found the lower bed of the Trias, a light colored conglomerate, containing pieces of unchanged granite. Above this conglomerate, the sandstones became fine-grained and uniformly red in color,§ showing that the shore line had progressed westward. In South Park the Red Beds nowhere rest on the granite; for, on the east side, the Dakota group rests on it, while on the west side the Paleozoic rocks are interposed as I have already stated. Continuing the section westward to the Elk Mountains we again find Paleozoic strata beneath the Trias, but south of the Elk Mountains both the Trias and the underlying Paleozoic are absent, and the Cretaceous is superimposed on the granite. Following down the Gunnison we find the underlying rocks coming in gradually until the Red Beds show resting on the granite. West of the Elk Mountains, between the Gunnison River and the Rio Dolores. the Trias rests on the granite, gradually thickening as we go westward. No lower strata are seen until we get within about five miles of the Dolores, when Upper Carboniferous strata appear, with every evidence that a shore line once existed there. The outcrop of Red Beds resting on the granite is exposed to view continuously for more than 20 miles. The fact that the Red Beds thin out and disappear as we go east, and that the Jurassic does the same until the Cretaceous alone rests on the granite, points to the fact that the sea was gradually encroaching on the land, and there must have been a subsidence here extending into Cretaceous time. South of the Gunnison River are small areas of Archæan rock where trachytic flows rest upon them with no sedimentaries interposed, and in others the Archæan rocks project through the trachyte forming isolated granite hills.

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* Report U. S. Geol. Survey, 1873, pp. 243–245, and Report of 1874, pp. 114–120.

† Report Expl. Exped. to junction of Grand and Green Rivers, pp. 17 and 42.

‡ Report U. S. Geol. Survey, 1873, p. 96.

§ Ibid., pp. 194, 195.

In South Park, on the west side as I have already said, the entire series of sedimentaries from Primordial to the top of the Cretaceous is present, while on the east side the Dakota group rests on the granite. Prof. Stevenson acknowledges that there was subsidence during the formation of the Triassic rocks, as far as the Front Range is concerned. He says, (p. 500), "In this region there was a subsidence during the deposition of the Trias which affected the interior little, if at all, for over the greater portion of that area the Trias is altogether wanting." Again he says, (p. 490), "In South Park the Cretaceous rocks rest directly upon metamorphic rocks, and are themselves more or less altered. At no locality were they seen resting upon any sedimentary rocks older than themselves." I have shown that Triassic rocks show at more than one locality in the interior. On the east side of South Park the Dakota Group rests on the granite, with shales above it containing well defined Cretaceous fossils. On the west side the Dakota Group rests on Jurassic shales, beneath which are the massive Red Beds of the Trias.*

Under the head of Carboniferous, Prof. Stevenson refers to exposures of coarse sandstones and siliceous limestones on the west side of the Park extending 8 miles east of the mountains, (p. 373), and under the head of Cretaceous he says, "In South Park the Cretaceous rocks occupy a synclinal trough, lying east from Fair-Play, and extending from the mountains at the north to very near the southern boundary of the park, (p. 389)." He does not appear to have seen the Jura and Trias between the Cretaceous and Carboniferous in South Park (see Reports U. S. Geol. Survey for 1873), or if he did, failed to recognize it, as I can find no reference to them under his heading Triassic and Jurassic, (pp. 378–382.)

In Middle Park, Mr. Marvine found the No. 1, Cretaceous

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* Report U. S. Geol. Survey, 1869, p. 79, and Report for 1873, pp. 38–47 pp. 212–239.

(Dakota Group) resting on the granite on both sides of the Park.[*] Following these outcrops farther north, in 1874, he found both Jurassic and Triassic beneath the Cretaceous on the granite, and on the west of the Park Range the whole series of sedimentaries is present.[†] Speaking of Middle Park he says,[‡] "As was first distinctly pointed out by Newberry (Amer. Assoc. Meeting, Newport, R. I., 1860, also later Proc. Amer. Assoc., Aug., 1873, p. 185, etc.), east of the range, so here in the Middle Park, the general aspect of the formation as a whole is that of a 'circle of deposition,' an encroaching shore line deposit of sandstones attending slow submergence, followed by a deeper water sediment forming slates and shales, but not reaching sufficient depth or attaining the proper conditions to develop extended limestone deposits; in turn followed by a shallowing sea with more arenaceous accumulations." The area of Middle Park, therefore, must have been above the level of the Triassic sea, whose shore line was north of the park but gradually encroaching on it, so that in Cretaceous time the subsidence was sufficient to allow the deposition of the Cretaceous rocks.

Prof. Stevenson says, (p. 500), "It is probable that following this upheaval [*at the close of the Trias*] an extensive subsidence took place over our whole area to admit of the deposition of the Cretaceous, which occurs not only on the plains but along all the old interior synclinal troughs and in the southwest region. The close of the Cretaceous was marked by violent disturbance throughout the greater portion of our area. Along the edge of the plains the dip of the rocks is from 10° to 20°, though in some localities the action was excessive, turning the strata on edge or pushing them over at Golden and the Garden of the Gods. In South Park a well defined synclinal was produced."

By referring to the sections in the Reports of the U. S. Geol. Survey for 1873 and 1874, it will be seen that the Lower Tertiary[‖] is conformable to the underlying Cretaceous. In South Park toward the northern end, in 1873, I found Lower Tertiary fossils in beds resting on the granite toward the east.[§] What the relations were to the Cretaceous at the west I was unable to determine on account of volcanic action. At some points along the eastern front of the Colorado Range, the Lower Tertiary overlaps the Cretaceous and rests on the granite.[¶] In Middle

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[*] See sections opp. p. 192, Report U. S. Geol. Survey, 1873.

[†] Unpublished geol. map of Colorado, U. S. Geol. Survey.

[‡] Report U. S. Geol. Survey, p. 156.

[‖] It is best to state here that by Lower Tertiary I mean the debatable Lignitic Group which Prof. Stevenson regards as Cretaceous.

[§] Report U. S. Geol. Survey, 1873, p. 219, and section Fig. 1, Plate VI opp. p. 212.

[¶] See line of coal *outcrop map of* base of mountains opp. p. 40, Report U. S. *Geol. Survey, 1874.*

Park Mr. Marvine found the Lower Tertiary and the underlying Cretaceous conformable except at one point.[*] In southwestern Colorado the Cretaceous and Tertiary appear to be conformable, while in the northwestern part of the state the strata were apparently conformable from the base of the Cretaceous to the middle of the Miocene. This may be because of the distance from the axis of elevation, the elevation not being sufficient to lift the area above the sea-level at the end of the Lower Tertiary. I have no evidence in any of my districts of any *violent* action at the close of the Cretaceous. The apparent unconformabilities at Golden and near Colorado Springs I have already explained. There are, however, evidences in some portions of Colorado, of disturbance toward the close of the Cretaceous; but it is not until the end of the Lignitic Period that we find evidences of a geological break.[†] There was probably, as indicated by Hayden and Newberry, an elevation commencing in early Tertiary time, for the marine deposits of the Tertiary change gradually to fresh-water deposits as we ascend, but there was no *marked* action until the close of the Lignitic. There must have been a subsequent depression, for east of South Park near Florissant, we find Miocene[‡] strata resting on granite, with no older beds beneath,[§] and on the Colorado divide, the Miocene rests on the granite of the Front Range and on the upturned edges of older strata. The lowest beds here, also, were evidently made from the material derived from the adjacent mountains. In Middle Park, Marvine found Tertiary beds resting on the granites and on Cretaceous shales, occupying all the lower basins. "Near the borders of these areas these beds often plainly show that their material was derived from the adjacent rock, often being of coarse granitic or schistose *débris*, or of the lignitic sandstones worked over."[‖]

From what I have written, I think it is evident that in Colorado, at the close of the Carboniferous, instead of an elevation there was subsidence commencing at some period prior to the close of the Carboniferous, and continuing through the Triassic, Jurassic, and Cretaceous into Tertiary time.

At the close of the Trias we have no evidence of a second epoch of elevation. The close of the Cretaceous was not marked by *violent* disturbance.

I agree with Prof. Stevenson that during the early Tertiary time there was great volcanic activity in Colorado.

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[*] Report U. S. Geol. Survey, 1873, p. 156.

[†] Report U. S. Geol. Survey, 1873, p. 157.

[‡] By Miocene I mean beds of the age of the Green River formation lying below the Bridger Group.

[§] Report U. S. Geol. Survey, 1873, p. 210.

[‖] Report U. S. Geol. Survey, p. 157.

The following conclusions are, I think, fairly deduced from the facts as noted in Colorado:

1st. In very early time in Colorado there was Archæan land rising above the Paleozoic sea. As the Carboniferous age progressed this land diminished by encroachment of the sea, due to subsidence of the land. This subsidence continued through Triassic, Jurassic, and Cretaceous time into the early Tertiary.

2d. At the close of the Lignitic there was a physical break followed by a subsidence (at least locally) and subsequently by elevation, after the deposition of the Miocene strata.

3d. The elevation of the Rocky Mountains as we now see them in Colorado, is the result of an elevation commencing in early Tertiary time, and continuing through the period, accelerated perhaps at the close of the Lignitic, and after the deposition of at least Lower Miocene strata.*

The elevation of the mountains was probably gradual as a general movement.

It is an interesting fact that Colorado has a higher mean elevation than any other State or Territory of the United States,† and that we find there the highest mass of mountains, and that the evidence points to the fact that in Paleozoic time also we had here one of the highest areas, thus confirming what Dr. Newberry has already intimated,‡ that the outlines of the western part of the North American Continent were outlined from earliest Paleozoic time.

ART. XXI.—*On some Points in connection with Vegetation*; by Dr. J. H. GILBERT.

[Concluded from page 111.]

Is the nitrogen combined under the influence of the soil with or without the aid of manures, the source of the assimilated nitrogen?—But if the plant itself cannot either assimilate free nitrogen, or effect its combination so as to bring it into a state for its use, may not such combination take place under the influence of the soil?

More than thirty years ago, Mulder argued that in the last stages of decomposition of organic matter in the soil, hydrogen was evolved, and that this nascent hydrogen combined with the free nitrogen of the air, and so formed ammonia.

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* This elevation is probably going on at present also.

† List of Elevations, by H. Gannett, U. S. Geol. Survey, Miscel. pub. No. 1, 3d edition, p. 47.

‡ See Ives Exploring Expedition, Geol. Rep., p. 47, also p. 57 of Macomb's Exploring Expedition to the junction of Grand and Green Rivers.

A few years ago Dehérain substantially revived this view. He maintained that at a certain depth the air of the soil is poor in, or destitute of, oxygen; that hydrogen is evolved from the decomposing organic matter; that it unites with free nitrogen to form ammonia; and, that so, combined nitrogen increases in the soil in spite of the growth and removal of crops. This view he supports by some laboratory experiments.

It is obvious that if the reality of this action in soils were unquestionably established, it would greatly aid the solution of the question we are discussing. There, are, indeed, results of others on record which would seem to lend it probability.

Thus, Bretschneider found, on exposure of a mixture of humic acid and quartz sand to the air for a whole year, under conditions in which it was protected from rain and insects, that there was a gain of combined nitrogen which would represent an increase of more than 40 lbs. per acre.

Again, Boussingault exposed a moist garden soil for three months, and found a small gain of nitrogen. His explanation, was, however, different. He supposed it possible that ozone might be evolved in the oxidation of organic matter in the soil, and unite with free nitrogen, and so nitric acid be produced, and the soil gain in combined nitrogen. In other experiments Boussingault put mixtures of vegetable mould and pure sand in small quantities in large glass vessels which he perfectly closed and preserved in a dark cellar for a whole year. At the end of that period oxidation of organic matter had taken place, nitric acid was found, but there was upon the whole a small loss of combined nitrogen. Lastly in regard to Boussingault's results bearing upon this point, it has already been shown that in all of his experiments with plants in which his soils consisted of ignited pumice, ignited brick, or the like, without organic matter, he found no gain of combined nitrogen in soil and plant. In 1858 and 1859, however, he made a number of experiments on growth, in which part of the soil consisted of rich garden mould; and in two cases with lupins growing in confined air, and in one with haricot growing in free air, his results showed a notable gain of combined nitrogen: and although the quantity of garden mould employed was not the same in the three cases, the gain of nitrogen was approximately in proportion to the amount of soil used. The gain was, indeed, in the soil rather than in the plant. In the other experiments, however, either much less, or no gain was indicated.

Much more recently, Boussingault has published the results of experiments which showed that when a garden soil was confined for about eleven years in closed glass vessels in an atmosphere containing oxygen, the free nitrogen did not serve for the formation of nitric acid within it; but, on the contrary, the soil lost a portion of its combined nitrogen.

Since the delivery of this lecture, M. Berthelot (Compt. Rend., t. lxxxii, p. 1357) has stated that in experiments in which he exposed moistened cellulose to an electric current in an atmosphere of nitrogen, he found nitrogen taken up, and a fixed nitrogenous body formed. Referring to the last mentioned experiments of M. Boussingault, and his conclusions from them, M. Berthelot objects that the soils being in closed glass vessels, the intervention of atmospheric electricity was excluded, and the conditions of the experiments were, so far, unlike those of a natural soil.

Being very desirous to know the present opinion of M. Boussingault on the various points involved in this important question of the sources of the nitrogen of vegetation, I wrote to him shortly after undertaking to give this address, and asked whether he would be kind enough to favor me with a statement of his views on certain points. Unfortunately his reply did not reach me until after the delivery of the lecture; but, with his permission, I am now enabled to contribute a very valuable addition to the discussion in the form of a translation of the more essential parts of M. Boussingault's letter. He says:—

"(1.) In confined stagnant air, or in air moving through a closed apparatus, after previous purification, but still containing carbonic acid, plants growing in a soil destitute of nitrogenous manure, but containing the mineral substances indispensable for the vegetable organism, do not assimilate the nitrogen which is in a gaseous state in the atmosphere."

"(2.) In the open air, in a soil destitute of nitrogenous manure, but containing the mineral substances necessary for the vegetable organism, plants acquire very minute quantities of nitrogen, arising, no doubt from minute proportions of fertilizing nitrogenous ingredients carried by the air, ammoniacal vapors, and dust, always containing alkaline or earthy nitrates."

"(3.) In confined stagnant air, or in air renewed in a closed apparatus, a plant growing in a soil containing a nitrogenous manure, and mineral substances necessary for the vegetable organism, or in fertile vegetable earth, does not assimilate free nitrogen."

"(4.) In field culture, where dung is applied in ordinary quantities, analysis shows that there is more nitrogen in the crops than was contained in the manure applied."

"This excess of nitrogen comes from the atmosphere, and from the soil."

"(A.) From the atmosphere, because it furnishes ammonia in the form of carbonate, nitrates or nitrites, and various kinds of dust. Theodore de Saussure was the first to demonstrate the presence of ammonia in the air, and consequently in meteoric waters. Liebig exaggerated the influence of this ammonia on vegetation, since he went so far as to deny the utility of the nitrogen which forms a part of farm-yard manure. This influence is, nevertheless, real, and comprised within limits, which have quite recently been indicated in the remarkable investigations of M. Schlösing."

"(B.) From the soil, which, besides furnishing the crops with mineral alkaline substances, provides them with nitrogen, by ammonia, and by nitrates, which are formed in the soil at the expense of the nitrogenous matters contained in diluvium, which is the basis of vegetable earth; compounds in which nitrogen exists in stable combination, only becoming fertilizing by the effect of time. If we take into account their immensity, the deposits of the last geological period must be considered as an inexhaustible reserve of fertilizing agents. Forests, prairies, and some vineyards, have really no other manures than what are furnished by the atmosphere, and by the soil. Since the basis of all cultivated land contains materials capable of giving rise to nitrogenous combinations, and to mineral substances, assimilable by plants, it is not necessary to suppose that in a system of cultivation the excess of nitrogen found in the crops is derived from the free nitrogen of the atmosphere. As for the absorption of the gaseous nitrogen of the air by vegetable earth, I am not acquainted with a single irreproachable observation that establishes it; not only does the earth not absorb gaseous nitrogen, but it gives it off, as you have observed in conjunction with Mr. Lawes, as Reiset has shown in the case of dung, as M. Schlösing and I have proved in our researches on nitrification."

"If there is one fact perfectly demonstrated in physiology, it is this of the non-assimilation of free nitrogen by plants; and I may add by plants of an inferior order, such as mycoderms, and mushrooms."

Numerous experiments of Schlösing indicate a similar result to that last quoted of Boussingault. He selected a soil rich in humus, containing about 16 per cent of moisture, and 0·263 per cent of combined nitrogen. Known quantities of it were placed in large wide glass tubes, and during a period of about four months, he aspirated over them air containing respectively from 1·5 to 21 per cent of oxygen. He determined the carbonic acid in the air passing off, and the nitric acid in the soil before and after the experiment. He found that both the combustion of the organic matter, and the formation of nitric acid, were very considerable, even with the lowest proportion of oxygen in the air; but that the formation of the nitric acid in particular was very much the greater, the larger the proportion of oxygen in the air.

In a second set of experiments, he used the soil in a moister condition; and instead of the experiment in which the air contained only 1·5 of oxygen, he employed pure nitrogen; and the experiments extended over a period of about six months. In the case in which the aspirated air contained no oxygen, the whole of the nitric acid previously existing in the soil disappeared; but in the other cases there was a considerable formation of nitric acid.

In a third set of experiments, Schlösing determined the nitric acid in the soils, and added known quantities of potassium nitrate in a dilute solution. The mixture was enclosed in a flask of several times the capacity of the volume of soil. At the conclusion of the experiment only traces, if any, of gas containing hydrogen and carbon were present in the air of the vessel. The amount of ammonia in the soil increased considerably, but in only small proportion to that which the nitric acid would yield. At the end of the first experiment more potassium nitrate was added, and an atmosphere of known volume and composition supplied. At the conclusion of this experiment the soil contained no nitric acid; the amount of ammonia was increased, but again in only small proportion to the amount which the nitrate would yield. There was indeed a loss of total nitrogen in the soil.

Schlösing concludes that the combustion of organic matter in the soil is accompanied by a loss of nitrogen: that the combustion may be at the cost of the air as in the experiment of Boussingault, or at the cost of nitrates, of ferric oxide, or of the oxygen of organic matter, as in his own experiments.

It will be seen that on this important point of whether or not the soil may acquire combined nitrogen either in the form of ammonia by the combination of free nitrogen with nascent hydrogen evolved in the decomposition of organic matter in defect of oxygen, or in the form of nitric acid by the oxydation of free nitrogen, the evidence is, to say the least, conflicting. The more recent results of Boussingault, and those of Schlösing, would, however, indicate a greater probability of a loss of combined nitrogen, and evolution of free nitrogen.

Judging of the probabilities by reference to some of the results of our own investigations, we think that they are rather against than in favor of the supposition that there is any material gain of the kind assumed by Mulder and Dehérain. It may be well, however, briefly to call attention to some few facts which seem to bear upon the point, whether in favor, or otherwise, of the view in question.

The action assumed by Mulder and Dehérain, if it have place at all in soils in their natural condition, would be supposed, and is assumed, by Dehérain, to occur in layers sufficiently deep to be poor in oxygen. In the lower layers of the soil there is, however, a deficiency of carbonaceous organic matter also. Again, if such formation of ammonia do take place, it is probable that some at any rate of it must be oxidized into nitric acid; a condition which, on the other hand, implies an atmosphere not poor in oxygen. Thus, numerous results of analysis of the drainage water from many of the experimental plots at Rothamsted, to which further reference will be made presently, show that nearly the whole of the combined nitrogen in the drainage collected at a depth of about thirty inches, exists as nitrates and nitrites; which, obviously, would hardly be the case if the solution passed through a considerable layer of soil, the interstices of which contained an atmosphere poor in, or destitute of, oxygen.

Again, assuming such formation of ammonia to take place in the upper layers of the soil, where there is the most organic matter, and much oxidation of it, the supposition would be that the conditions would favor oxidation rather than the formation of ammonia from free nitrogen; and the fact of the formation of a good deal of nitric acid by the oxidation of nitrogenous organic matter, or ammonia, in the surface soil, is sufficiently established.

Further, if it were to the action assumed by Mulder and Dehérain taking place in the upper layers of the soil that we owe the supplies of combined nitrogen available to leguminous and other plants which assimilate so much more of it over a given area than the Gramineæ, the question may be asked—why cannot the Gramineæ avail themselves of this superficial supply? On this point it may be mentioned that, on some parts of the experimental wheat and barley fields at Rothamsted, farm-yard manure has been applied year after year, for a quarter of a century or more, in quantity containing perhaps six or seven times as much nitrogen as is removed in the increase of crop, and that thus the percentage of nitrogen in the surface soil has been more than doubled. Yet, as large a produce of barley, and a larger produce of wheat, is annually obtained by the use of very much smaller quantities of nitrogen, as ammonia-salts or nitrate. It would thus appear that the nitrogen of the farm-yard manure was only available to the cereals after its transformation into ammonia or nitric acid. Unfortunately, we are not at present able to adduce direct experimental evidence as to the condition in which the large amount of inefficient nitrogen exists in the soil, or as to whether a leguminous crop would or would not grow luxuriantly in it, but there is little doubt that it would do so. On the other hand, a good crop of clover would appear to be attainable in soil comparatively poor in nitrogen in its upper layers, and comparatively poor in organic matter also; for, in the experiments already referred to in which barley was grown after barley and after clover, the large amount of clover obtained, and nitrogen assimilated in it, was after six corn crops grown by artificial manure alone; conditions under which the amount, both of available nitrogen, and of organic matter, in the upper layers of the soil, would be supposed to be comparatively small.

The answer of Dehérain would probably be, that under the circumstances supposed, the nitrogen would be in a condition of combination not favorable for assimilation by the Gramineæ; that, in fact, the ammonia formed would combine with organic acids in the soil, yielding compounds specially favorable as food for the Leguminosæ. An objection to this view is, that if the accumulation in the soil by time, of nitrogen in a condition specially favorable for the Leguminosæ were such as is here assumed, we should expect the amount of nitrogen in the soil, determinable by the soda-lime process, to be higher before than after the growth of a leguminous crop; whereas, on the contrary, after the growth of a leguminous crop, the amount of nitrogen so determinable in the upper layers of the soil is very appreciably increased.

The evidence in favor of the supposition that the special source of nitrogen to the Leguminosæ is ammonia, or other compounds than nitric acid, in the upper layers of the soil, is then, to say the least, inconclusive. It remains to consider whether it may not be nitric acid, either in the soil or in the subsoil?

As already said, there is abundant evidence of the formation and existence of a considerable amount of nitric acid in surface soils; even in such as contain a relatively high amount of carbonaceous and nitrogenous organic matter. For example, a soil at Rothamsted which has been under garden cultivation, and as such probably manured almost every year for centuries, has successfully grown clover every year for more than twenty years. This soil was shown by the late Dr. Pugh, and has been again recently by Mr. Warington, to contain a considerable amount of nitric acid. But such a soil would, there is no doubt, grow large crops of Gramineæ also; which direct experiments show to attain great luxuriance under the influence of artificially applied nitrates. But such a rich garden soil contains an abundance of every thing—mineral constituents, carbonaceous organic matter, and combined nitrogen in various forms, and thus the exact conditions which it supplies favorable to the Leguminosæ cannot at once be discriminated.

The fact of the comparatively little, or at least uncertain action of directly applied nitrates on the growth of the Leguminosæ, would seem to be inconsistent with the supposition that it is the nitric acid in such a surface soil that has given it its special adaptation for the growth of clover for so many years—unless, indeed, it be the case, that it is much more available to such crops when in combination with some bases than with others.

The next point to consider is, whether there are any facts in favor of the supposition that clover, and leguminous crops generally, acquire any material proportion of their nitrogen in lower layers, and in a more extended range of the soil, than the Gramineæ. As an element in the discussion of this question, it will be well in the first place to call attention to the effects of direct nitrogenous manures, such as ammonia-salt, or nitrates, on the growth of some of our crops.

In Table VIII is shown the estimated amounts of carbon, yielded per acre per annum, in wheat over twenty years, in barley over twenty years, in sugar-beet over three years, and in beans over eight years; each with a complex mineral manure alone, and each with the same mineral manure and given quantities of nitrogen in addition, supplied in some cases in the form of ammonia-salts, and in others as nitrate. The gain of carbon by the use of the nitrogenous manure is also given.

TABLE VIII.—*Estimated yield and gain of Carbon per acre, per annum, in experimental Crops at Rothamsted.*

Manuring, Quantities per acre, per annum.	Average Carbon per acre, per annum.	
	Actual	Gain.
Wheat 20 *years*, 1852–1871.		
	lbs.	lbs.
Complex Mineral Manure	988	
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	1590	602
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	2222	1234
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	2500	1512
Barley 20 *years*, 1852–1871.		
Complex Mineral Manure	1138	
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	2088	1150
Sugar-Beet 3 *years*, 1871–1873.		
Complex Mineral Manure	1136	
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	2634	1498
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	3081	1945
Beans 8 *years*, 1862 *and* 1864–1870.		
Complex Mineral Manure	726	
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	992	266

It is quite evident that in the case of the gramineous crops, wheat and barley, which contain a comparatively low percentage of nitrogen, and assimilate a comparatively small amount of it over a given area, and also in that of the sugar-beet, there was a greatly increased amount of carbon assimilated by the addition of nitrogenous manure alone. In the case of the wheat, there is much more effect from a given amount of nitrogen supplied as nitrate, which is always applied in the spring, than from an equal quantity as ammonia-salts, which are applied in the autumn, and are subject to winter drainage. There is also more effect from ammonia-salts applied to barley than to wheat; the application being made for the former in the spring and for the latter in the autumn. There is again more effect from the nitrate than from the ammonia-salts when applied to sugar-beet, the application being made in both cases at the same date, in the spring.

On the other hand, the effect of the nitrogenous manure upon the highly nitrogenous bean crop is seen to be, comparatively, very insignificant.

In reference to this point, it should be observed that there has been this greatly increased assimilation of carbon in the wheat and in the barley for more than twenty years, without the addition of any carbon to the soil. It is indeed certain that, in the existing condition of our soils, the increased growth of our staple and starch-yielding grains is greatly dependent on a supply of nitrogen to the soil. It is equally certain that the increased production of sugar in the gramineous sugar-cane, in the tropics, is likewise greatly dependent on the supply of nitrogen to the soil.

In reference to the great increase in the assimilation of carbon in the sugar-beet by the use of purely nitrogenous manures, it may be of interest to observe that over the three years of the experiments with sugar-beet, the increased production of sugar per acre per annum was about 20 cwts. by the use of 82 lbs. of nitrogen per acre per annum as ammonia-salts, and about 28 cwts. by the use of 82 lbs. of nitrogen as nitrate of soda.

It is then our characteristically starch and sugar-producing crops that are the most characteristically benefited by the application of nitrogenous manures; while our highly nitrogenous leguminous crops are comparatively little benefited by such manures.

Proportion of nitrogen of manure got back by the increase of crops.—But now let us consider what is the proportion of the nitrogen supplied in manure that we get back in the increase of the crops that are most specially benefited by its use?

In Table IX is shown the amount of nitrogen recovered, and the amount not recovered, in the increase of crops for 100 supplied in manure, to wheat, and to barley, respectively; the result being in each case the average over a period of twenty years.

TABLE IX.—*Nitrogen recovered, and not recovered, in the increase of Produce, for 100 supplied in Manure.*

Manuring, quantities per acre, per annum.	For 100 Nitrogen in Manure.	
	Recovered in Incr'se.	Not Recovered in Incr'se.
Wheat 20 *years*, 1852–1871.		
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	32·4	67·6
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	32·9	67·1
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	45·3	54·7
Barley 20 *years*, 1852–1871.		
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	48·1	51·9

Speaking generally, it may be said that, nothwithstanding the great effects produced by the nitrogenous manures, two-thirds of the nitrogen supplied were unrecovered in the increase of crop when the ammonia-salts were applied to wheat; the application being made in the autumn. When, however, nitrate of soda was used, which is always applied in the spring, the quantity left unrecovered was not much more than half that supplied. With barley also, the manuring for which takes place in the spring, there is again nearly half the nitrogen supplied in the manure recovered in the increase, and therefore little more than half left unrecovered.

It may be observed that, in the case of root-crops, when the supply of nitrogen is not excessive, the proportion of the nitrogen of the manure recovered in the increase may be much greater than in the case of the cereals; while in the case of the Leguminosæ the effects of such direct application of soluble nitrogenous manures to the surface soil is comparatively so small, and so uncertain, that it would be useless to give an estimate of the amounts recovered and not recovered respectively.

But what becomes of the one-half or two-thirds of the nitrogen supplied for the increased growth of the cereals, but not recovered in the increase of crop? Dr. Frankland and Dr. Voelcker have made numerous analyses of the drainage water from the experimental wheat plots which have yielded the results above referred to, and a summary of their results is given in Table X.

TABLE X.—*Nitrogen as Nitrates and Nitrites, per* 100,000 *parts of Drainage Water from Plots differently manured, in the Experimental Wheat Field at Rothamsted, Wheat every year, commencing* 1844.

Manuring, Quantities per acre, per annum.	Nitrogen as Nitrates and Nitrites, per 100,000 parts Drainage Water.					
	Dr. Frankland's Results.		Dr. Voelcker's Results.		Mean.	
	Experiments.		Experiments.		Experiments.	
Farm-yard Manure	4	0·922	2	1·606	6	1·264
Without Manure	6	0·316	5	0·390	11	0·353
Complex Mineral Manure	6	0·349	5	0·506	11	0·428
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	6	0·793	5	0·853	11	0·823
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	6	1·477	5	1·400	11	1·439
Complex Min. Man. and 123 lbs. nitrogen, as ammonia	6	1·951	5	1·679	11	1·815
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	5	1·039	5	1·835	10	1·437

The figures in the Table conclusively show that the quantity of nitrogen as nitrates per 100,000 parts of the drainage water, increased in very direct proportion to the increase in the amount of ammonia or nitrate supplied, and it is obvious that there has been a considerable loss of the nitrogen of the manures by drainage. But as the subsoil rests upon chalk not many feet below the surface, and there is, therefore, natural drainage constantly going on, even when there is no flow from the pipes, it is impossible accurately to estimate the total amount of drainage, and therefrom the total amount of loss. Other experiments at Rothamsted, however, lead to the conclusion that, according to season, from one-quarter to nearly one-half of the annual rainfall may pass below 40 inches. Now, supposing drainage water to contain one part of nitrogen as nitrates per 100,000 parts of water, an inch of rain passing beyond the reach of the roots would carry with it 2¼ lbs. of nitrogen per acre; and it is obvious that if from seven to ten inches passed annually of that average strength, the loss would be very great. In reference to this point it is of much interest to observe, that in the Report of the River's Pollution Commission already referred to, Dr. Frankland gives a series of analyses of land drainage waters collected at Rothamsted, at depths of twenty, forty, and sixty inches, respectively; and those collected at twenty inches, almost invariably show much more nitrogen as nitric acid than those taken at either forty or sixty inches. It would thus appear to be indicated that a considerable amount of nitric acid has been arrested in the soil below the depth of twenty inches. Further, determinations of nitrogen in the soils do show some accumulation. Indeed, it would appear probable, that the whole of the nitrogen applied to the wheat as ammonia salts or nitrate of soda, was either recovered in the increase of crop, or may be accounted for by determinable accumulation within the soil, or by loss by drainage.

In ordinary agriculture, the amounts of soluble nitrogenous manures applied would generally be much less than in some of these special experiments; and the losses by drainage would from that cause alone be proportionately less than that shown above. Much, obviously, would also depend upon the character of the soil and of the subsoil. Again, in an ordinary rotation of crops, more of the supplied nitrogen would probably be gathered up before it reached the lower layers, than in the case of a cereal crop grown year after year on the same land. It may be safely concluded, however, that whenever cereals were grown, a material proportion of the nitrogen specially applied to, or existing in the soil, which would be available to other crops, would not be so to them; but would in the first instance accumulate in the surface soil, and gradually pass into the lower layers in the form of nitrates, to be eventually lost by drainage if not arrested by some other crop.

The question obviously arises, whether we have not here a source of some at least of the nitrogen available to leguminous or to other plants having possession by their roots of a greater range of subsoil than the Gramineæ. We have evidence enough that although wheat and barley send roots down very deep into the subsoil, and pump up moisture from the deeper layers, they nevertheless derive much of their nitrogen within the surface soil. If the Leguminosæ do not so readily do so, or at any rate naturally depend more upon the nitrogen in the lower layers for a considerable proportion of that which they require, and moreover are able to avail themselves of the residue from the manuring for other crops, what is the nature of the problem that we may have to solve to elucidate this point?

By way of illustration it may be mentioned that, supposing a leguminous crop to acquire 100 lbs. of nitrogen per acre from a layer of subsoil three feet in thickness, weighing approximately 10,000,000 lbs. (exclusive of stones and water), this would represent only ·001 per cent of nitrogen so acquired in such subsoil; 200 lbs. of nitrogen per acre so available would represent ·002 per cent, and so on. Now, even supposing that the nitrogen existed in the subsoil in such a condition as to be converted into ammonia in the process of combustion with soda-lime, the difference between one subsoil containing this, or even a larger amount of nitrogen, more than another, could not with certainty be determined by that process; for, in taking say 15 or 20 grams of the subsoil for combustion, the difference between two or more determinations could not be expected to be less than some units in the third decimal place (per cent); that is, in fact, equal to the total amount that may be in question as between two subsoils to be compared. Further, if this available nitrogen exist in the subsoil as nitrates, it may be a question whether there would be a sufficient amount of organic matter present to insure the evolution as ammonia of the nitrogen of the nitric acid.

It has been shown, then, that there are many questions still open for investigation in regard to the relations of the surface soil to combined nitrogen; and there are obviously also equally important points to investigate in regard to the nitrogen of the subsoil, before we can hope to arrive at a satisfactory solution of some of the problems which the consideration of the facts of vegetable production which have been adduced, suggest for enquiry. Nor are the problems still open connected with the amount, and the condition, of the mineral food of plants within the soil, either few, or without special, and independent interest. And although those relating to the nitrogen seem to call for the first attention, the marked effects, so far, of potash manures, in increasing the amount of nitrogen assimilated over a given area by the Leguminosæ, seem to indicate the probability that even the difficulties connected with the sources of the nitrogen of our crops may not be solved without further knowledge as to the required conditions, or the actions, of the incombustible or mineral constituents in soils.

More extended investigation required.—Our results in regard to the variations in the amount of nitrogen in the soils and subsoils of our different experimental plots, obtained by the soda-lime process, together with the results already referred to, relating to the composition of the drainage water from plots variously manured, as well as others of quite a different kind, have shown the absolute necessity for an extended investigation of the soil question by more exact methods; and Mr. Warington is about to devote, probably some years, to this enquiry at Rothamsted. It is proposed that the questions relating to the nitrogen in subsoils should be the first considered, since, if the results do throw light upon some of the points at present in doubt, a definite step in advance will be so gained; and should they not do so, the ground will thus be cleared of certain obvious suppositions, and the course of further research will be the more clearly indicated. But if the amount of nitrogen to be discriminated should prove to be represented by only units in the third decimal place per cent, say ·002 for example, it is obvious that to get as little as four milligrams involved in the analysis, 200 grams of soil would have to be operated upon. The difficulties of the problem are thus sufficiently obvious. But, by the aid of the processes of water and gas analysis which have been explained by the President in his opening address, there is little doubt that they can be overcome, at any rate so far as the nitrogen existing as nitric acid is concerned; and by the kindness of Dr. Frankland, Mr. Warington is at the present time gaining experience in the use of those methods, in the laboratory of the College of Chemistry, before entering upon this special investigation at Rothamsted.

But even supposing we arrive at a satisfactory solution of the, at present, unsettled points in regard to the sources of the nitrogen yielded in agricultural production, when, as in the experiments to which attention has been directed, we have a soil to work upon which already contains accumulations of combined nitrogen amounting to several thousands of pounds per acre within the range of the roots of our crops, further questions in regard to the nitrogen may still be left open, namely,—to what actions a large proportion of the existing combined nitrogen may be attributed; and what in particular is the exact source of the accumulations of it in our soils and subsoils? And here it may be observed, in passing, that determinations made at Rothamsted have shown approximately the same percentage of nitrogen in the Oxford-clay obtained in the recent Sub-Wealden exploration boring at a depth of 500 and 600 feet, and in the subsoil at Rothamsted, taken a depth of about 4 feet only.

It is not within the scope of the present discourse to discuss fully what is known of the actual or possible sources of the already existing combined nitrogen, the special object of the enquiry being, as intimated at the commencement, to bring to view the facts relating to the yield of nitrogen in agricultural production, which the extended period of the investigations of Mr. Lawes and myself have enabled us to establish, and to point out the relation of this to the various known or supposed sources of present periodic supplies, so as to indicate what points seem the most urgently to demand further investigation. In the papers already referred to, we have more fully considered what was known of the various actual or possible sources of the combined nitrogen which we know to exist, and to circulate, in land and water, in animal and vegetable life, and in the atmosphere, and we have pointed out how little was established of either the actual or the relative importance, in a *quantitative* sense, of the various actions by which it is admitted that free nitrogen may in nature be brought into combination. I may, however, observe that M. Boussingault and M. Schlösing have quite recently made interesting contributions to the discussion of this subject. (Compt. Rend., t. lxxvi, lxxx, lxxxi, and lxxxii).

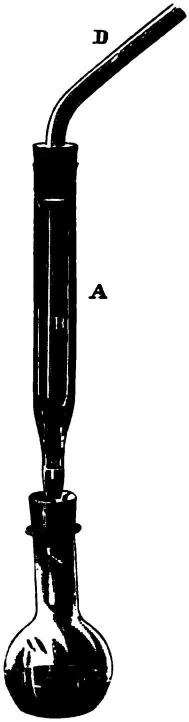
But whatever may be the origin of the existing combined nitrogen, or whether or not the agencies of its formation are more or less active now than during the earlier history of the earth and its atmosphere, the question arises whether, assuming the origin to be independent of the direct action of vegetation, the large accumulations within our soils and subsoils, admits of any reasonable explanation? On this point it may be remarked, that ages of forest growth, or of the growth of natural herbage only grazed by animals, would doubtless leave the soil richer year by year; as the amount annually lost to it would probably be less than even the small amount known to be annually deposited from the atmosphere, in temperate regions, at the present time; and the accumulation would probably be greater still, were the amounts of combined nitrogen in the atmosphere, and brought down from it, greater than with us at the present time. Then, again, the influence on aqueous deposits of ages of submarine vegetation, and of the subsistence of animal life upon it, has to be considered. But a soil once broken up, and under arable culture, it is difficult to conceive of any system of agriculture by which so little nitrogen as that hitherto quantitatively determined to be annually deposited from the atmosphere would be annually exported from the land.

Conclusion.—And now, to summarize in a few words the results of the whole discussion, I think the balance of the evidence points to the conclusion, that the answer to the question—what are the sources of the nitrogen of vegetation in general, and of agricultural productions in particular, is more likely to be found in the relations of the atmosphere, and of the plant, to the soil, than in those of the atmosphere to the plant itself.

One word more in conclusion. I have, as explained at the outset, confined attention almost exclusively to one aspect of the great subject of vegetation; but it will not be supposed that I have done so from any want of appreciation of the interest and importance of other lines of inquiry; and allow me, before closing to allude to a point which can hardly fail to suggest itself on an inspection of the numerous organic compounds, made by transformation in the laboratory, which are collected in the Chemical Section of this Exhibition. Without in the least degree disparaging such work, I would ask whether some of those who have become masters of such transformations, might not with advantage, armed with the experience thus gained, now devote themselves to the study of the transformations going on within the plant and the animal? In other words, whether it would not be desirable, that some of the thought and labor now expended on transformations in the chemical laboratory should be transferred to the laboratory of nature?

ART. XXII.—*Apparatus for quantitative Fat-extraction; On the Composition of the Sweet Potato; On the Composition of Maize Fodder;* by S. W. JOHNSON.—*Contributions from the Sheffield Laboratory of Yale College.** No. XLIII.

I. *Apparatus for quantitative Fat-extraction.*



THE apparatus consists of a glass tube A, of ¾ to ⅞ in. bore and 6 to 7 in. long, narrowed at bottom to a bore of ¼ in., and there fitted by a cork to a flask C, of 80 c. c. capacity, and connected above by a cork with a reversed Liebig's condenser D. Within A a similar but smaller tube B is maintained free from the sides of the larger tube, either by three knobs of glass fused upon it where it begins to narrow, by a support of platinum foil as in the figure, or by suspension with help of a wire looped around the upper part of B and a hook depending from the cork above it. B is closed below either by a plug of cotton or asbestus or else by a disk of filter paper supported by one of muslin tied over its narrow and slightly flanged end. The substance to be extracted is introduced into B, 50 c. c. of ether or other solvent are placed in the flask and heat is applied to boil the liquid. Its vapor passes into the condenser, and there liquefies; the liquid drops continuously upon, and percolates the contents of B, carrying into C any dissolved matters, whence it rises again as vapor to be again condensed and repeat the solvent action.

The cooling must be effectual and the heat applied to the flask just sufficient to maintain a regular circulation of the solvent. B may be weighed with its contents, after closing the end by means of corks or rubber caps. To dry its contents it may be connected at one end by means of a perforated stopper and tube to an apparatus for supplying pure hydrogen, at the other by a rubber tube several inches long and $CaCl_2$ tube to an aspirator, and may be heated by immersion in an inclined position in a bath of boiling water, while a slow stream of dry gas is transmitted. The loss in weight of B and its dried contents may in some cases give the amount of oil extracted more speedily and accurately than direct veighing of the latter. For ordinary quantitative fat-estimaions A and B may be made from stout test tubes.

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* *The substance* of these papers was read at the Detroit meeting of the *American Association* for the Advancement of Science, in August, 1875.

This apparatus is not only easier to construct and to handle han those which have a separate interior or exterior tube to arry up the ether-vapors, but has the additional advantage hat the substance to be extracted is kept warm by being contantly surrounded with hot vapor.

It is best to mount the apparatus so that it may be put into a omewhat inclined position if needful, as then by revolving the pparatus on the condenser tube D the stream of condensed olvent may be directed in succession on all parts of the contents of B and any channels that may form are easily broken up.

In milk-analyses I have followed the fat-extraction by similar treatment with 80 per cent alcohol for the separation of sugar.

II. *On the Composition of the Sweet Potato.*

The Sweet Potato (*Convolvulus batatas* or *Batatas edulis*) is an esculent of great value to the United States. It is not only at home in all the Southern States, but is produced in large quantities in Central New Jersey, and Central Illinois, latitude 40°; and has been successfully raised in gardens in nearly the coldest parts of New York, as well as in Maine and Southern Minnesota (St. Paul), in latitude 44° to 45°. It is probable that under northern cultivation varieties may originate more adapted to cold climates, so that were it needful its profitable cultivation might be extended several degrees of latitude northward, as is said to have happened in Europe with regard to maize, for which it is asserted that 46° north latitude was formerly the limit, whereas now it is cultivated nearly to 52°.

The Sweet Potato is known in many varieties which differ widely in quality. Naturally, the kinds which are propagated at the north are less sweet and less highly flavored than those produced in a warmer climate. The New Jersey and Delaware sweet potatoes which are marketed in New England, though palatable and largely consumed, are decidedly inferior to the produce of Virginia. I am informed that sweet potatoes of excellent quality are raised in Southern Illinois, lat. 37°–38°, while those produced in Central Illinois, lat. 40°, are "watery" and comparatively insipid.

The sweet potato in highest repute at the north is the Nansemond, taking its name from the southeastern county of Virginia, where it is said to have originated. The "Nansemond Improved," raised in Hanover Co., Va., is the finest variety of this esculent that has come under my notice. I am indebted to John Ott, Esq., of Richmond, Va., for abundant samples of this variety, the high quality of which has induced me to undertake its analysis.

The composition of the sweet potato has been studied by Proust, Einhof, Payen, Henry, Fromberg, and Antisell.

Their analyses were mostly made by methods less perfect than those we now possess, and they differ from each other to a degree not explained by the variations in quality of the sweet potato itself, and some of them are evidently incorrect. Since there is to my knowledge no printed summary of these older analyses I have thought it worth while to reproduce them.

As chemists are too well aware, no unexceptionable methods for separating or estimating some of the organic principles of our esculents have as yet been discovered. Since the tendency of newer researches points to the existence in plants of a series of isomeric bodies with the denser and maturer forms of cellulose at one extremity and dextrin at the other, with various celluloses, starches, amylodextrins and dextrins intermediate, which defy separation and have long resisted identification, the best that can be done in proximate analysis is to follow some method conventionally agreed upon, by which fairly comparable results may be reached. The analysis of the "Nansemond Improved" was made essentially according to the plan adopted by the German Agricultural Experiment Stations, and the results have been for the most part verified by repetition and critical examination of the educts. This analysis has regard only to the more important food-principles, without reference to traces of malic acid, etc., which have been reported in former examinations.

For analysis, about 600 grams of the tubers were thinly sliced (in December, 1874), air-dried in a warm room and then pulverized. In 5 grams of air-dry substance, water was estimated by three methods.

1. By drying at 100° C. in a flask exhausted by the Bunsen-Sprengel pump. This method, which leads speedily to the desired result in case of other vegetable matters, e. g., maize-meal, hay, etc., required several days for bringing sweet-potato flour to a constant weight.

2. By drying in air-bath at 125° C. This process speedily removes the water but occasioned browning of the substance.

3. By drying at 100° in a stream of hydrogen, a method somewhat tedious but less so than 1, and now adopted by many of the German Experiment Stations.

The three methods gave of loss on air-dry substance:

1	7·19 per cent.
2	6·90 " 7·13 "
3	7·54 " 7·19 "
Average =	7·19 "

The total loss of *water* experienced by the fresh substance = 73·39 per cent.

Fat was extracted from the dried-residue of the water-estimation, by treatment with carbon disulphide in the apparatus before described. The process required twelve hours for completion. Two trials yielded 0·26 and 0·31 of a soft yellow substance, appearing at first like a pure fat, but which to the feel and taste had more of the properties of wax than of the ordinary fats. It probably resides chiefly in the laticiferous tissue, whose yellow juice is evident on a fresh section of the sweet potato.

An aqueous extract of the sweet potato was obtained by digesting four grms. of finely-pulverized air-dry substance with nearly half a liter of cold water for five hours and filtering. The residue was treated with a similar quantity of cold water for twelve hours more. Aliquot portions of the two extracts were separately evaporated in capsules and dried at 212° F. The first extraction was practically complete, as the second digestion took up but 3·5 mgr., or a little more than $\frac{1}{10}$ per cent of soluble matters. The total amount of solid aqueous extract, after deducting ash, was 7·94 per cent.

The aqueous extract was brown in color and perfectly clear. Boiled, it gave a very slight precipitate, acids made it turbid, and Millon's test gave a faint red tint to the liquid on heating. Iodine gave no coloration. Basic lead acetate gave a copious precipitate, separating in flocks on boiling, and in the filtrate Fehling's solution gave reddish-yellow precipitate on boiling. These reactions indicate presence of a trace of albuminoids, of gum* and of a glucose. They exclude starch, amylodextrin and dextrin.†

To effect proximate separation of gum and sugar, a portion of aqueous extract was evaporated to dryness, taken up in a very little water and treated with 80 per cent alcohol. Sugar was recovered by evaporation of the alcohol solution. As is known, this separation is a rough one. The sugar obtained gave on boiling with Fehling's solution, at once, a copious flocky-red precipitate. Set aside in concentrated solution it showed no signs of crystallization. It therefore largely consisted of a *glucose*. Its amount was 6·86 per cent. The substance remaining insoluble after a second treatment with alcohol, which was mostly *gum*, was 1·08 per cent of the fresh tuber.

Cellulose was determined by alternate treatment of the powdered substance with dilute (2 per cent) sulphuric acid and caustic soda solution, in the usual manner. Combustion, with the mixture of equal bulks of sodium carbonate and slacked lime, gave 0·187 and 0·207 per cent of nitrogen, which multiplied by 6·25 leads to the content of *albuminoids.* Starch was estimated by difference. The summing up is as follows:

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* The term gum is used in a generic sense. The substance obtained appeared to have more nearly the characters of arabin than of pectin or other gummy body, being highly soluble in water.

† See Nägeli, Beiträge zür näheren Kentnisse der Stärkegruppe, p. 103.

Water	73·39
Starch, by difference	15·06
Gum	1·08
Sugar (levulose?)	6·86
Cellulose	0·98
Albuminoids	1·28
Fat and wax	·28
Ash	1·07
	100·00

Table I includes all the analyses of the sweet potato that I have been able to find.

In the older analyses, 1 to 6, the figures for starch and cellulose are of no value because they were the results of an attempted mechanical separation. In fact these analyses are worthless for any purpose, except as regards the water and sugar estimations. Fromberg's figures for water are too exceptional to have any claim to accuracy.

As already mentioned, the figures in analyses 6 and 7 are so coincident in regard to several ingredients, and so plainly wrong in 6, as respects ash, that they must both be considered untrustworthy. Whether the low amounts of water in 8, and of sugar in 9, and the high percentages of sugar in 8 and of starch in 9, are analytical errors or characterize the sweet potato in its different varieties, remains to be established by future comparative investigations.

In the common potato (*Solanum tuberosum*) a range of water content from 68 3 to 82·1 per cent, and of starch-content from 15 to 26 per cent has been observed.

In nutritive values the Hanover sweet potato and the common potato on the average differ but little. Their comparative composition is as follows:

	Sweet potato.	Potato.
Water	73·4	74·6
Albuminoids	1·3	2·2
Fat and wax	0·3	0·2
Carbohydrates	23·0	21·2
Fiber	1·0	0·7
Ash	1·0	1·1
	100·0	100·0

The average composition of the common potato is that given by Dietrich and König in their *Zusammensetzung und Verdaulichkeit der Futterstoffe.*

	Gasparin, Cours d'Agriculture, t. iv, p. 58.	Ure's Dict. of Arts, Am. ed., article Potato.	Liebig's Handwörterbuch, 2d ed., 2 Bd., 1 Abth., article Batate.	Johnston's Lect. on Ag. Chem., 2d Edinboro ed., p. 909.	White? Hamm's Landwirthschaft, Bd. 2, p. 165.	Payen et Richard, Precis d'Agriculture.	Yellow (Yam?)[12] Deherain, Chimie Agricole, p. 159. Pelouze et Fremy, Cours de Chimie, 2d ed., t. vi, pp. 292–3.	Red.	Report of Dept. of Agricult're, 1869, p. 75.	Co., Va. Yellow Nansemond
Water	72·0	74·3	73·1	59·31	71·25	74·00	79·64	67·50	73·00[14]	73·39
Starch	9·5	15·1	13·3	16·62	17·00	9·42	9·42[13]	16·05	19·16	15·06[15]
Cellulose	14·5[1]	8·2	6·8	12·88[4]	8·55[7]	2·54	0·54	0·45	1·98	0·98
Gum	----	----	----	0·55[5]	----	1·30[9]	1·30[9]	1·10[9]	----	1·08
Cane Sugar	4·0[2]	----	3·3	7·99	3·20	1·45	3·50	10·20	4·35	----
Grape Sugar	----	----				1·04			----	6·86
Albuminoids	----	0·8	0·9	2·66[6]	----[8]	1·10	1·10	1·50	0·35	1·28
Fat (wax)	----	----	1·1	----	----	0·89	0·25	0·30	0·24	0·28
Ash	----	----	----	....	----	13·69[10]	3·25	2·90	0·92	1·07
Total	100·00	98·4	99 9[3]	100·01	100·00	105·43[11]	99·00	100·00	100·00	100·00

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[1] With starch, "parenchyme amidonne."

[2] "Matter soluble in water."

[3] Including "1·4 % malic acid."

[4] "With a little oil and coagulated albumin."

[5] "Dextrin."

[6] "Impure caseine." By estimation of nitrogen, Fromberg calculated 2·27 % albuminoids.

[7] Given as "fibrine" obviously a mistake for "fibre."

[8] Nitrogen is given at 0·199 %, equal to 1·25 albuminoids.

[9] "Pectic acid with organic matter."

[10] Includes 6·48 % salts and 7·00 malates of potash and ammonia, as quoted by Gasparin, Cours d'Agriculture, p. 59. Sacc, Cours de Chim. Agricole, gives water 7·3 % and 'salts and malates' 9·26.

[11] The total is given by Payen and Richard as 103·43.

[12] Deherain gives this as an analysis of the "Batate (Convolvulus batatas)," Pelouze and Fremy as an analysis of the yellow yam, "Igname jaune."

[13] The correspondence of the figures for starch, gum, albuminoids and cellulose between this and the preceding analysis, and the excess of 5·43 % in 6, indicate some confusion which I cannot unravel.

[14] Antisell analyzed "sweet potato flour" containing 7·95 % water. He calculated the composition of the sweet potato fresh, assuming 65·96 % water. I have calculated the results of his analysis on 73· % water, for the sake of better comparison.

[15] Estimated by difference.

The sweet potato is possibly more easily digestible than the common potato, because of containing nearly 7 per cent of soluble sugar in place of a similar amount of starch. Its sweet taste is mentioned by European writers as a reason why it does not enter more largely into the produce of southern France, and probably for most inhabitants of temperate regions it does not relish so well in constant use as does the common potato, which, like bread, appears daily and twice daily on the tables of the Middle and New England States, as well as on those of England, Germany and France. The sweet potato is, however, in its best varieties a most inviting esculent, and perhaps "wears" better than any other vegetable save the common potato. Its juices are so rich in sugar that the tuber keeps poorly, for wherever the cuticle is broken, the common omnipresent fungi take root, under favorable conditions of temperature and moisture, and rapidly penetrate the tissues, producing discoloration and dry or wet rot. French authorities report that the potato-fungus, *Peronospora infestans*, attacks the sweet potato as vigorously as the common.

III. *On the Composition of Maize Fodder.*

The use of maize as a fodder plant is very extensively practiced in this country as well as in South Germany and Austria. In the latter countries maize fodder appears to be uniformly regarded as a valuable resource to the farmer. In the United States, however, some excellent farmers have denounced it for various reasons; some because of the difficulty of securing the crop, and others because of its supposed innutritious quality. In fact, chemical analysis has been employed to show that maize is a comparatively worthless fodder crop.

These considerations induced me to undertake its investigation, and I have been fortunate in finding highly suitable material on the farm of J. J. Webb, Esq., near New Haven, Conn., as well as the most hearty assistance in preparing the fodder for analysis at the hands of that gentleman. Two samples, raised from separate plantings and on separate fields, were placed at my disposal. The variety of maize was the Southern or Norfolk White; the seed was obtained from Long Island. No. 1 was raised on long tilled ground and inverted sod, with help of stable manure. No. 2 was taken from new ground, which had borne two rye crops, was seeded, had been in pasture for five years, was then plowed and had carried two successive crops of corn fodder, of which it was of course the last. To the soil that yielded No. 2 no stable manure had ever been applied. No. 2 was sown 10 to 15 days earlier than No. 1, and was more mature at the time of cutting the samples, Sept. 1st, 1874.

In planting, three bushels of seed were sown per acre, in drills 24 inches apart. When harvested the stalks had an average height of 10–12 feet. Many stalks measured 14 feet in length. Their diameter was very uniform, rarely more than 1¼ inch at the base.

The corn thus planted and growing under clean tillage was so mature and uniform that it admitted of easy and perfect curing, and yet at the same time was so tender and palatable that little or no loss occurred in feeding. When harvested the corn-fodder contained a good many imperfectly developed ears, some of them with nearly ripe kernels.

The corn on cutting was set up in the field in large carefully made stooks, where it remained until Nov. 11, when it was removed to the barn in good order. The samples were obtained by cutting off in each case an area of 10 feet square, including 5 rows and a length of 10 feet on each row.

The stand of the crop was so uniform, both horizontally and vertically, as to ensure a very accurate result in sampling.

Each sample was made into bundles which were at once weighed, labeled and set up in the field as parts of a stook. When the crop was housed the samples were again weighed. They remained in the barn until February, 1875, when the use of corn-fodder began for the winter. They were again weighed on February 8th, and immediately were run separately through a straw-cutting machine, which reduced them to half an inch lengths, and in that state were brought to the laboratory.

Each sample was then carefully intermixed and weighed portions were taken for analysis. The portions were reduced to tolerable fineness by passing repeatedly through a sausage-cutter and by the use of shears, and for the nitrogen estimations were further pulverized by triturating with purified quartz sand. The proximate analysis for water and cellulose was conducted as mentioned in the previous paper. "Ether extract" was obtained by the extraction apparatus already described. Ash was determined by incineration at a dull red heat in a platinum dish.

The results of the analyses, calculated upon the material in the different stages of dryness in which it was weighed. are the following:

	Fresh cut. Sept. 1, 1874.		Field-cured. Nov. 11, 1874.		In Barn. Feb. 10, 1875.		Dried. Water-free.	
	1	2	1	2	1	2	1	2
Water	87·18	85·04	27·59	26·92	53·76	54·95		
Ash	0·84	0·74	4·76	3·62	3·04	2·24	6·57	4·95
Albuminoids	0·88	0·78	4·97	3·79	3·18	2·34	6·87	5·19
Fat, etc., (ether extract)	0·28	0·22	1·55	1·07	0·99	0·66	2·14	1·46
Cellulose (crude)	4·38	5·16	24·76	25·18	15·81	15·52	34·19	34·45
Carbohydrates, etc., by difference	6·44	8·06	36·37	39·42	23·22	24.29	50·23	53·95
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The further examination consisted in extracting the pulverized fodder with water, evaporating the solution, to determine total quantity of soluble matters, redissolving in a little water and treating with 80 per cent alcohol to throw down gum.

This treatment was carried out both with cold and hot water. The results were as follows, calculated on dry substance:

	1 Water. Cold.	 Hot.	2 Water. Cold.	 Hot.
Total extract	1·49	22·27	2·01	26·54
Ash	·47	5·21	·31	4·41
Soluble in alcohol, starch, sugar, fat, etc.,	·80	10·87	1·48	21·51
Insoluble in alcohol, gum	·22	6·16	·22	·62

The water extract gave a reaction with Fehling's solution, showing the presence of a little sugar. The alcohol precipitate when redissolved in water gave no reaction with Fehling's solution but contained a trace of albuminoid.

Starch is carried into solution by boiling with water, and soluble gum is more completely extracted by the hot maceration of the imperfectly pulverized material.

These laborious trials were not duplicated, and it is not fully established whether the absence of gum in 2 is the result of a possible error in analysis or the consequence of maturer development of stalks. The larger quantity of hot water extract in 2 is not improbably due to the presence of seed kernels with abundant starch.

The results agree fairly with the average of a number of analyses made of late years in Germany and Austria, which, however, doubtless refer usually to a much smaller plant and crop.

The subjoined statement gives: A, the average of my two analyses; B, the average of the German analyses as given by Wolff, Fütterungslehre, 1874; C, the average given by Dietrich and König, 1874. All refer to the fresh fodder.

	A.	B.	C.
Water	86·1	82·2	85·0
Ash	0·8	1·1	1·0
Albuminoid	0·8	1·2	1·8
Ether extract (fat and wax)	0·3	0·5	0·6
Cellulose	4·8	4·7	4·4
Carbohydrates, etc.	7·2	10·3	7·2
	100·00	100·00	100·00

Total Yield.—The following figures give the gross produce of the two crops upon an area of 100 square feet as ascertained by Mr. Webb's weighings, and also the produce, per acre, (found by multiplying these weighings by $\frac{43560}{100}$) as well as the quantities of water and dry matter in the fodder at the several times of weighing.

	Crop 1.			Crop 2.		
	100 sq. ft.	1 Acre.		100 sq. ft.	1 Acre.	
	lbs. oz.	lbs.	tons.	lbs. oz.	lbs.	tons.
Fresh cut, Sept. 1	124–4	54,123	27	117–4	51,074	25 5-10
Containing water	108–5*	47,184	23 1-2	99–11*	43,418	21 7-10
Field-cured, Nov. 11	22	9,583	4 8-10	24	10,454	5 2-10
Water	5–1*	2,244	1 1-10	6–7*	2,798	1 4-10
In barn, Feb. 8	34–7	15,028	7 1-2	38–15	16,988	8 5-10
Water	18–8*	8,089	4	21–6*	9,327	4 7-10
Dry	15–15†	6,939	3 1-2	17–9‡	7,661	3 8-10

Werner, Handbuch des Futterbaues, p. 602, gives the yield of uncured maize fodder in Germany and Austria in four instances, as follows: 50,000, 72,000, 72,000 and 52,800, or an average of 60,000 kilos. per hectare. This average equals 53,440 lbs. per acre. One of the crops of 72,000 kilos. equal to 64,129 lbs. per acre, made 14,000 kilos. of cured fodder, "maize hay," equal to 12,470 lbs. per acre. The loss of water in curing was 80½ per cent of the fresh cut maize. This indicates that the crop was thickly sown, probably on very rich ground, and was cut in a quite immature and watery state.

It is noticeable that the less mature crop 1, weighed fresh 1½ tons more than 2, but when field-cured 2 was 870 lbs. heavier than 1. Crop 2, field-cured, contained 1½ per cent more water and also 3 per cent more carbohydrates, etc., than 1. The autumn weather during which the fodder stood in the field was exceptionally fine and dry. After storing, the weather of the winter was very rainy and damp, and for that reason the loosely packed fodder gathered moisture, so that the average 5 tons of fodder as it was stored Nov. 11, became 8 tons as it lay in the barn Feb. 8, after exposure for three months to the damp winter air. This gain of water was greatest with 2, amounting to more than 3½ tons for the produce of an acre, and being one-half as much water as the green fodder lost in field-curing, and as much as the field-cured fodder contained at the time of storing. Such variability in the water content of a harvested crop appears to be unexampled.

The objection urged against corn fodder that it is innutritious does not apply in respect to the *total yield* of dry matter, for to obtain 3$\frac{65}{100}$ (average of 3½ and 3$\frac{8}{10}$) tons per acre of dry matter from other forage, would require a crop of 4 tons of meadow hay, and 4¼ tons of clover hay, admitting these to contain 8 and 12 per cent of water respectively.

As respects nutritious *quality*, the corn fodder is very different from meadow or clover hay. To make the nature of the difference evident, I subjoin the average analyses of the dry matter of German hay and maize fodder,§ and an average of the two analyses of Mr. Webb's corn fodder.

* Nearly. † More exactly 15$\frac{93}{100}$ lbs. ‡ More exactly 17$\frac{54}{100}$.

§ From Dietrich & König's Zusammensetzung und Verdaulichkeit der Futterstoffe.

	German.			Mr. Webb's.
	Meadow hay.	Red clover.	Maize fodder.	Maize fodder.
Ash	7·7	7·4	6·7	5·8
Albuminoids—so-called flesh-formers	11·8	16·6	12·4	6·0
Fat	2·7	2·7	3·7	1·8
Cellulose—woody fiber	29·9	30·1	29·3	34·3
Carbohydrates, starch, gum, sugar, etc.	47·9	43·2	47·9	52·1

It is seen from the above figures that the German meadow hay and the German corn fodder are almost identical in composition. Clover hay differs from them in containing some four per cent more of albuminoid and four per cent less of carbohydrates. Mr. Webb's maize fodder contains but one-half as much albuminoids and fat as the German, while its cellulose and carbohydrates are each four to five per cent more. This difference between the two statements of maize fodder depends simply on the fact that most of the German analyses were made on less mature maize. Some of the German analyses give but 0·9 per cent of albuminoids in fresh fodder, the same result as in Mr. Webb's 1 (0·88).

How greatly age influences the content of albuminoids in forage plants is shown by the fact that meadow grass quite young as it is found in pasturage contains in its dry matter 24 per cent of albuminoids, cut just before bloom 12 per cent, and at end of blossoming but 8 per cent. In case of both maize fodder and meadow grass the inferior quality of the older vegetation is compensated by their superior quantity.

Such maize fodder as Mr. Webb produces is valuable when properly employed. Used as a substitute for meadow hay it would be pronounced, and deservedly so, poor cattle food, but as an ingredient of a properly compounded ration it has a high value. In New England, hay commands a high price in the cities and large towns, and is therefore adapted to sell off rather than to consume on the New England farm. The farmer can raise or buy Indian corn, cotton-seed meal, and other concentrated foods, and combine them with coarse fodder to make a cattle food equal or superior to the best of hay, at less cost than is involved in feeding the latter. To throw cured maize fodder out in the cattle yard or to feed it in the stall as hay is fed, is likely to be highly wasteful. To attempt to sustain cattle on it alone or to employ it as an adjunct to hay is also a mistake. To use it profitably it must be finely cut and well mixed or alternated with maize or cotton-seed meal, bran, or some similar material which serves at once to ensure its large consumption and the full economy of its nutritive qualities. Maize-meal and similar articles contain too much albuminoids, fat and starch, for healthy and economical cattle food. Maize fodder contains too little of these and too much coarse fiber. The mixing of the two in proper proportions enhances their separate value and makes a more perfect nutriment, and under New England circumstances doubtless an economical cattle food.

The digestibility of cellulose in the alimentary apparatus of herbivorous animals has not only been amply established by numerous feeding trials in the agricultural experiment stations of Germany and Austria, but the relative digestibility of the cellulose and other food-elements of various kinds of cattle food has been the subject of repeated experiments. The method of these investigations consists in determining by chemical analysis the amount of cellulose, etc., contained in the ingested food and the amount that passes off in the solid excreta. The difference is the quantity digested. It has been found as the average of some 45 experiments on oxen, cows, goats and sheep, that 62 per cent of the cellulose of meadow hay is dissolved in the digestion of these animals and serves as food, while as the average of 18 trials but 46½ per cent of the cellulose of red-clover hay is digested. In a single trial Moser found that 72 per cent of the cellulose of maize fodder was digested by sheep. One result is not conclusive as to the comparative digestibility of maize fodder, because this quality is influenced by the maturing of the plant, and by the individuality of the animal, as well as by the proportion of food-elements in the ration; but it indicates a high nutritive power.

Moser's results in regard to the other ingredients of maize fodder show that the sample he worked with was in all respects more digestible than the average meadow or clover hay, except these are cut before blossom, and was, roundly speaking, twice as digestible as the straw of the cereal grains.

I am indebted to my friend and late assistant, E. H. Jenkins, M. A., for carrying out the details of the foregoing analyses.

XXIII.—*On the Meteoric Stone of Rochester, Fulton County, Indiana;* by Charles Upham Shepard, Massachusetts Professor of Natural History in Amherst College.

A FALL of a meteoric stone took place at about 8:45 Thursday evening of the 21st of December, 1876. The circumstances connected therewith are drawn from several communications.* The first is from Professor Daniel Kirkwood, of Bloomington, Indiana, Professor of Mathematics in the Indiana State University, as published in the Indianapolis Journal. Professor Kirkwood's account says: "Last evening, Dec. 21, about 8:45 o'clock, our citizens witnessed a meteoric display of extraordinary brilliancy. A fire-ball, described by many observers as surpassing the moon in apparent magnitude, followed by a great number of smaller meteors, was seen in the northern heavens, moving in an easterly direction. Its first appearance was at a point 12° or 15° north of west, and about 10° above the horizon. Its greatest altitude, as seen from Bloomington, was about 18° or 20°, and its disappearance occurred at a point in the northeast, some 5° or 6° above the horizon. A remarkable feature of the meteoric group was the slowness of its apparent motion. The time of flight was variously estimated. Most observers, however, think it could not have been less than three minutes. Many of the meteors following in the train of the principal bolide were larger than Venus or Jupiter. No attempt was made to count them, but their number was certainly nearly one hundred. Some minutes after the disappearance a rumbling noise was heard, which was supposed to result from the meteor's explosion."

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* See also this volume, p. 166.

The second is from the Columbus (Ohio) State Journal.

"A meteoric display, which, for singularity and beauty, few persons in a lifetime have the good fortune to behold, was witnessed by six or seven persons, myself included, on the evening of the 21st inst., at just 9 o'clock. Four of us were in the caboose car, and two or three others on the engine of the freight train, due in Columbus at 9:20 P. M., on the Cleveland, Mount Vernon and Columbus Railroad, and within about four miles of the depot. At that point the track runs nearly north and south. The cluster or flock of meteors, from forty to sixty in number, varying in apparent size from a water-bucket down to the size of large apples, were seemingly huddled together like a flock of wild geese, and moved with about the same velocity and grace of regularity. The color of their light was a yellowish red, resembling the light from the red balls of fire thrown out by the explosion of some kinds of sky-rockets. There was no illumination, nimbus, or trail from them. The display was a little below an angle of 45 degrees from our point of observation, and seemed not over a quarter of a mile distant from the rear end of our train. The course was from west to east, crossing the railroad at nearly right angles. The party on our engine, and our conductor, who was looking out of the rear window of our car, made the discovery at about the same moment, in a westerly direction. When seen by the rest of us, the meteors were just passing over the track and very slowly approaching the earth. I cannot pretend to put this statement in scientific form, having witnessed it from a moving train, but simply state the facts as they appeared to myself and others as worthy of note."

The third notice attended one of the specimens sent me, and consists of a letter addressed to Professor Kirkwood, from Mr. A. J. Norris, the finder of this stone.

"Enclosed you will find a specimen of the meteorite. The circumstances under which the stone was found are these. Hearing a rumbling noise, I stepped out of the house, and heard the stone fall. I marked the direction of the sound, and the next morning repaired to the field whence it had proceeded, where I discovered it lying upon the snow. I saw two places where it had previously struck, and from whence it had bounded to its resting place. No appearance of any other stone was visible in the region. Its weight was about three-quarters of a pound."

The following is from a letter (dated Bloomington, Ind., Jan. 19th) from Professor Kirkwood to myself:

"You were kind enough to express a wish that I would furnish you some notes in regard to the meteor. I have written many letters of inquiry, to some of which I have received replies. I have also a number of newspaper accounts of the phenomenon. I regret to say, however, that many of the statements made by observers are so inaccurate and contradictory as to be of little value. Being busy with other matters, I placed nearly all of them in the hands of Professor Wylie. The following conclusions, derived from the observations at Bloomington, Indiana, and Wooster, Wayne County, Ohio, can be relied upon as nearly correct:

Rev. Dr. Wylie, Professor of Natural Philosophy in the Indiana State University, noticed the point in a tree apparently passed by the meteor. The angle of elevation was subsequently measured, and found to be about 15 degrees. But the meteor passed our meridian 131 miles north. These data, making allowance for the curvature of the earth's surface, give about 38 miles as the height of the body when passing the boundary line between Pulaski and Fulton Counties, Indiana. At Wooster, Wayne County, Ohio, the meteor apparently passed a particular point of the steeple of a public building. From this observation the apparent altitude when over Lake Erie, immediately north of the city, was found by Professor Samuel J. Kirkwood to have been about 24 degrees, corresponding to a true height of 28 or 29 miles.

The most western point from which I have received a report is Emporia, Kansas. It passed that place a few degrees S. E. of the zenith. I think the meteor became visible over the N. W. corner of Texas, at an elevation of 70 or 80 miles. The estimates of time for the meteor are so discordant that it seems impossible to determine whether it was moving in an ellipse, a parabola, or an hyperbola."

Description of the Rochester Stone.

It belongs, by way of eminence, to my order of Oolitic, of the class Litholites, and resembles most closely the Pegu (India) stone of December 27, 1857, particularly in the character of its crust and in its pisiform external structure. The two stones are not unlike in color and in the facility with which they may be broken, both yielding to separation when in small masses, under the mere strength of the fingers. The thickness of the crust in each is double that in the majority of litholites. The general tint of color is also the same in both. In the Rochester stone, however, the shade is less gray, from the greater prevalence of an almost pulverulent, nearly white mineral, in which the dark ash-gray globules are imbedded. This white mineral forms less than one-tenth of the mass. The globules vary in size from a millet-seed up to that of a pepper-corn. Their shape is almost perfectly spherical, and plainly indicates an origin from fusion, the surfaces of many of them being obviously mammillary, while internally they present a porcelainous, compact structure.

The globules are probably forsterite, of a variety nearly identical with boltonite. This appears the more likely from the circumstance that those situated just below the crust have the yellowish tint acquired by boltonite after its subjection to heat with access of air; and it is presumable that this alteration of the globules in the meteorite took place on its entrance into our atmosphere when the fusion of the surface occurred.

The white semi-pulverulent basis of the stone I take to be Chladnite ($\dot{M}g^2\dddot{S}i^3$). In one of my specimens, it shows itself at a single point in its characteristic loosely crystalline structure; and there closely resembles this species as seen in the Bishopsville (March 25, 1843) meteorite.

The metallic iron (chamasite?), as in the Pegu stone, is very obvious; and rather evenly distributed, though probably not exceeding one per cent in quantity. In place of being in shapeless grains or points, or in curved wire-like fibers, it is semi-crystalline in structure, showing occasional rectangular and triangular facets. Troilite is barely visible at two minute points in the specimens thus far examined. Two distinct grains of Chrysolite, of the size of half a rice grain, are present, showing in each case the cleavage, color and luster of this species, as existing in Krasnojarsk meteoric iron. Moreover, these grains have not the perfect spherical form of the forsterite globules.

The specific gravity of a fragment, whose surface was one-third crust, is 3·65. It may be added in conclusion, that the inspection of this rather peculiar stone strongly suggests the idea that the pisiform globules were produced by the sudden fusion of what was originally a chladnitic material (similar to the Bishopsville stone), amid particles of chamasite attended by access of oxygen, whereby the silicate of magnesia became converted into the more fusible double silicate of magnesia and iron.

New Haven, Conn., Jan. 22, 1877.

ART. XXIV.—*Examination of the Waconda Meteoric Stone, Bates County Meteoric Iron and Rockingham County Meteoric Iron;* by J. LAWRENCE SMITH, Louisville, Ky.

THE meteorites under consideration have been known for some little time, Prof. C. U. Shepard having given a notice of the Waconda meteoric stone in this Journal of June, 1876, he having acquired the larger portion of it; the remainder has been kindly presented to me by G. W. Chapman.

The existence of the Bates County meteoric iron was announced by Prof. G. C. Broadhead (this Journal, Nov., 1875) to whom I am indebted for a large portion of the original mass.

Waconda Meteorite.

One feature to be noticed in connection with this meteoric stone is that the time of its fall is not known; it having been discovered in a ravine near the village of Waconda in Kansas (lat. 39° 20′, long. 98° 10′). While there are three or four of these softer meteoric stones, consisting almost exclusively of stony matter, the exact time of whose fall is not known, there is every reason to suppose that their falls were observed, and that they were collected at the time; but falling in remote places, and in the lands of those not accustomed to note precisely the dates of natural phenomena, the exact date of the fall was forgotten when it reached those who were interested in these bodies.

In the present instance nothing was known to lead to its discovery, and it was simply gathered up by an inhabitant of a sparsely settled region and laid aside on account of its singular appearance, and was only recognized as a meteorite some time afterward by one who had some knowledge of these bodies. Although but recently brought to notice, it was discovered two years ago, and I am inclined to believe that its discovery must have been made not very many months after its fall, as otherwise it would have undergone more thorough decomposition; as it is, the interior is marked with large blotches of oxide of iron arising from oxidation of the particles of iron by the water penetrating from without.

This exposure has doubtless had something to do with its friability as a whole, for many parts of it are quite firm where the iron is not oxidized, and, as Prof. Shepard says, it has the average cohesion of this class of meteoric stones. As he has already given a general description of it, I will not repeat it here, but proceed at once to give my chemical and mineral analyses.

The specific gravity of pieces from the interior varied from 3·4 to 3·6, and when separated mechanically consisted of—

Stony matter	90·81
Nickel iron	5·34
Troilite	3·85

The amount of the last mineral was made out by chemical analysis. The nickel iron contains:

Iron	86·18
Nickel	12·02
Cobalt	·91
Copper	·04
Phosphorus	not estimated.

The stony part treated with large excess of aqua regia gave:

Soluble part	69·00
Insoluble part	41·00

Composed of—

	Soluble.	Insoluble.
Silica	34·52	54·02
Protoxide of iron	30·01	18·10
Magnesia	32·50	23·45
Alumina	0·43	2·30
Manganese	·61	·36
Soda with trace of potash and lithia	·89	1·58
Lime		*trace*

The analysis clearly shows that the stony part of this meteorite consists of the usual mixture of olivine and pyroxene minerals; the hyalosiderite predominating in the former, and bronzite in the latter.

Two minerals were detached in small quantities and analyzed separately. The first was a dark colored mineral, readily seen in small parcels and veins; this, freed as far as possible from the adhering minerals, was found to be soluble in strong hydrochloric acid, and the prolonged action of this acid on the mineral, heated over the water bath, decomposed it very nearly completely; it is composed as follows:

Silica	41·10
Protoxide of iron	27·20
Magnesia	28·31
Alumina	·80
Manganese	·32
Soda	1·35

Its solubility in chlorhydric acid, and its composition, clearly point it out to be of the olivine type.

The other mineral was found only on one part of my specimens and there in the form of a white crystalline mass not exceeding in weight 20 milligrams; it looked at first sight like enstatite, but there was sufficient difference in its aspect to lead me to detach a few milligrams and test it: when I found it readily and completely soluble in hydrochloric acid, and as far as it was possible to decide on so minute a quantity it appeared to consist only of silica and magnesia.

Its solubility shows clearly that it is not enstatite, and I can only imagine it to be of the olivine type and consisting entirely of silica and magnesia, occupying the same place among the unisilicates of the meteorites that the enstatite does among the bisilicates. I simply note this fact here, not as giving any very definite result but simply that it may be looked into by those investigating these subjects.

Bates County Meteoric Iron.

This meteoric iron was first made known by a short note in this Journal, Nov., 1875, p. 401. It was discovered near Butler, in Bates County, Missouri (lat. 38° 20′, long. 94° 22′). The mass as it reached me had been in a blacksmith's forge, it having been heated for the purpose of cutting off a piece. It weighed about eighty pounds and was of an irregular form, with nearly equal diameters in all directions; it had a thick coat of rust on the surface; the metal is very tough and when cut across, numerous nodules of troilite were found on the interior free from any schreibersite. The Widmanstätian figures are readily developed, and are very large and regular.

Its specific gravity is 7·72. Its composition is—

Iron	89·12
Nickel	10·02
Cobalt	·26
Copper	·01
Phosphorus	·12

Some of the troilite was detached but not analyzed; its specific gravity is 4·73.

Rockingham County Meteoric Iron.

This meteoric iron was first brought to my notice, in 1870, by Prof. W. E. Kerr, the geologist of the State of North Carolina; but a short time afterward, seeing a notice of it by Dr. Genth in the Proceedings of the Academy of Sciences of Philadelphia, and as he proposed giving a further description of the same at some future time, I laid aside my notes concerning it; but having been frequently asked for particulars in relation to it from those possessing specimens, I have concluded to publish the notes made at the time it came into my possession.

This iron was discovered in Rockingham County, North Carolina, on a spot known as Smith's Mountain, two miles north of the town of Madison, about lat. 36° 20′, long. 79° 45′. It was found by Mr. Peters, from whom Prof. Kerr obtained it about the year 1863, and was lying on the surface of an old field which had been out of cultivation less than twenty years, and for that reason it is supposed it may have fallen within that time. It weighed originally about eleven pounds and was covered with a coating of rust. Its structure is highly crystalline, and when polished and either heated or acted on by nitric acid furnishes remarkably fine Widmanstätian figures, with delicate markings on the inside of the figures, which I designated sometime ago as Laphamite markings, having first observed them on the Wisconsin iron.

This iron contains narrow seams of schreibersite that penetrate the mass for several centimeters in different directions, some of them being two or three millimeters in thickness. In one part of the iron I discovered some solid chloride of that metal, enough to test its nature, and I detached a small fragment, that is now in the Museum of the Garden of Plants at Paris. It attracted moisture after being taken from a crevice in the iron, and became quite soft. This is the second time I have observed this solid chloride in meteoric iron. The nickeliferous iron, constituting the mass, exhibits the characteristics common to iron meteorites, viz: more or less diversity in the character of the iron in different parts, these varieties being so intimately associated that we possess no means of separating them. Dr. Genth considers it as composed of three different kinds of iron.

I selected a fragment perfectly free from any schreibersite visible to the eye; it gave a specific gravity of 7·78, and on analysis was found to contain—

Iron	90·88
Nickel	8·02
Cobalt	·50
Copper	·03
Phosphorus	·03

This will be seen to correspond to the analysis of Dr. Genth before referred to, which was as follows:

Iron	90·41	
Nickel (cobalt)	8·74	
Copper	0·11	
Iron	0·27	Phosphide insoluble in chlorhydric acid.
Nickel cobalt	0·33	
Phosphorus	0·14	

ART. XXV.—*Certain features of the Valleys or Water-courses of Southern Long Island;* by ELIAS LEWIS, Jr.

THAT portion of Long Island which lies southward of its central range of highlands, extending from near its western extremity to the Shinecock hills, is a plain, nearly level, traversed by numerous shallow valleys or water-courses. There are about thirty of these valleys, well defined, in a distance of fifty miles, between East New York and Riverhead, making one for a little less than two miles. In the lower end of most of them are flowing streams of singularly pure water, supplied by underdrainage of the region. The point where the springs break out in the valleys represents the surface of saturation in the soil. Above this point the valleys are dry excepting rarely when streams occur from surface-drainage during freshets, or from melting snow when the ground is frozen.

Few of these valleys are more than twenty feet in depth; their source is uniformly upon the high grounds, whence they extend southward to the bay. In some cases they may be traced nearly across the bay beneath its shallow waters to the verge of the ocean, affording evidence of a recent subsidence of the coast. A very marked peculiarity in their form is the steepness or abruptness of the banks upon their westerly sides, and the very gradual declivity of those upon their easterly sides. This feature is so obvious that it has long attracted the attention of travelers, and of others acquainted with this part of the island; and we know of no exceptions to it which cannot be explained by local conditions, such as may have arisen from confluence of streams or similar causes.

Another interesting feature of the valleys is their general direction. With some local exceptions their general trend or direction is a little west of south, and observation of them throughout their length renders it clear that this trend has arisen from some general cause acting during their erosion. The westerly or right banks have been eroded and worn away by the streams which formed the valleys, and now that the streams have ceased to erode them the steep banks remain.

The long declivities upon their easterly sides prove that the axis of the stream was originally several rods, in some cases from an eighth to a fourth of a mile eastward of where the axis, or deepest part of the valley now is. The phenomena we are considering cannot be explained by any merely local cause with which we are acquainted. The valleys are of post-glacial formation, and are in stratified gravels and sands distributed during the Champlain subsidence, and were probably formed as the coast gradually emerged from the water at the close of that period.

Features such as we have described have frequently been noticed in river valleys, but we are not aware of any instance where so large a number of short valleys, none of them more than ten miles long, present in so striking a manner the peculiarities mentioned.

That the cause is a general one seems probable. As suggested by Prof. Dana, who recently visited the island, the form and direction of the valleys in question may have arisen from the combination of motions to which Prof. Kerr of North Carolina attributes similar phenomena in the south-eastward flowing streams of that state. "The cause," Prof. Kerr observes, "is doubtless the rotation of the earth upon its axis co-acting with the river current." To a like combination of motions Prof. Maury, in 1855, referred some of the phenomena of ocean currents. The principle is the same that is exemplified in the circulation of ocean waters, in which, as a writer observes, "Any waters flowing from the polar regions (where the earth's motion is slow) toward the equator, would be thrown mainly against the west side of the oceans * * for they have no power to keep up with the earth's motion."

A similar result occurs with southward flowing streams over the land. For this reason the bank upon the west side of the stream is continually driven against it, in consequence of which the bank is abraded by the current, and worn away.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Rock-crystal Balance-beams, Thermometers, and graduated Circles.*—Stein, who, in 1874, proposed the manufacture of standard linear measures and weights in rock crystal, now goes farther and suggests the manufacture of balance-beams, graduated circles for telescopes, theodolites and quadrants, and even thermometers, of this material. With reference to weights, he states that the spherical form has been adopted in preference to the cylindrical, for many reasons, among others, because it is cheaper. For balance-beams, and scale-pans, the lightness of quartz, 2·65, is in its favor, aluminum being only 2·61; moreover its unalterability by chemical agents is complete. The construction presents no special practical difficulties. Graduated circles are cut from a quartz crystal perpendicular to the axis. For thermometers, a rod like that used for the linear unit can be bored lengthwise and the tube polished, an enlarged reservoir being made at the bottom for

ry, and the top closed with an air-tight stopper of the erial.—*Ber. Berl. Chem. Ges.*, ix, 1824, Jan. 1877.

G. F. B.

lution of Hydrogen at both Electrodes in Electrolysis.—R has made the curious observation that if a wire of m be made the anode in a decomposition cell containing diluted sulphuric acid, a wire of platinum being made de, hydrogen gas is evolved at both electrodes, though at only half as much gas appears as at the cathode; and ratio, though the total evolution of gas varies with the rength, remains constant. The same result happens lace of the sulphuric acid, a moderately dilute solution sium sulphate is used; only in this case, magnesium hy- eposited at both electrodes. Direct quantitative experi- wed that the quantity of magnesium dissolved at the rresponded exactly to the quantity of hydrogen set free e volume of hydrogen evolved at the cathode being the that set free in a voltameter in the same circuit. The ence believes that the positivity of the magnesium is so by the current that it combines not only with the et free by this current, but also with additional oxygen, gen which was united to it, appearing in the free state. wever, this hydrogen should be exactly one half of that t the cathode, is a question not yet capable of explana- r. *Berl. Chem. Ges.*, ix, 1818, January, 1877. G. F. B.

tion of the Molecular weights of Chemical substances to t-absorbing power.—AYMONNET has examined a number liquids and also a number of solutions, with a view to their power of absorbing heat, in order to trace some con- etween this property and their molecular weights. The s were concentrated upon a slit half a millimeter wide, ed through a tank containing the liquid to be examined, ugh a lens and prism, producing a spectrum. A thermo- g an opening one millimeter wide was moved millimeter eter along this spectrum, the deflection of the needle stantly noted. From the data thus obtained the amount ransmitted is calculated; the difference between the re- n the tank is full and empty being due clearly to the n of the liquid within it. The author concludes: 1st, molecular absorbing power appears to be constant: (A) lementary bodies when dissolved in the same medium; or elementary bodies which compose substances of analo- nical constitution. Among other physical results, he has that when the temperature of a source of heat of known is raised, the absorbing power of bodies submitted to tions from this source all diminish in the same ratio.— . *Ch.*, II, xxvi, December, 1876. G. F. B.

he Existence of Solid Particles of Carbon in Luminous -HEUMANN, in his fourth paper on the theory of luminous flames, considers at length the question of the nature of the light-emitting material in luminous hydrocarbon flames, and concludes that it is really solid incandescent particles of carbon. The proofs he offers are: 1st, the increased luminosity which chlorine gives to weakly luminous or non-luminous flames, due to its well-known property of separating the carbon as such. 2d, a rod held in a flame is smoked only on the lower side, the side opposed to the gas stream; were the carbon there as vapor, as Frankland assumes, it would be condensed by a cooling action and so all around the rod. 3d, a body held in the flame is smoked even when it is in a state of ignition; this therefore cannot be condensation of a vapor. 4th, these particles can be actually seen in the flame when it is made to strike against a second flame or an ignited surface, these particles aggregating together to form visible masses. 5th, the luminous portion of a flame is not very transparent, no more so than the layer of smoke of the same thickness which rises above a flame fed with turpentine. And 6th, flames which unquestionably owe their luminosity to the presence of solid particles give a shadow with sunlight, precisely as do hydrocarbon flames; while luminous flames composed of ignited gases and vapors only, give no such shadow in sunlight.—*Liebig's Annalen*, clxxxiv, 206, Dec. 1876. G. F. B.

5. *Alcohol from the Leaves of the sugar-beet.*—PIERRE, assuming that the sugar found in the beet-root must be elaborated by the leaves, has examined these leaves for sugar. Owing, however, to the difficulty of preparing the sugar as such, he subjected the juice expressed from these leaves to fermentation, and from the alcohol obtained, estimated the quantity of sugar. The leaves employed were collected in November, and weighed 158 kilograms. They yielded 34 to 35 liters of juice, which after fermentation, gave 275 cubic centimeters of alcohol of 68 per cent. Calculating from these data, each hectare of land would furnish about 173 liters of absolute alcohol, as a minimum.— *C. R.*, lxxxiii, 1075, Dec. 1876. G. F. B.

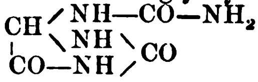
6. *On the Detection of ordinary Alcohol in Wood Spirit.*—BERTHELOT gives the following simple method of recognizing the presence of ethyl alcohol in wood-spirit. The suspected mixture is heated with twice its volume of concentrated sulphuric acid, and the gases evolved collected. If they consist solely of methyl ether, they will be entirely absorbed by water or by concentrated sulphuric acid; but if alcohol be present, ethylene will be formed which is insoluble in these menstrua under these conditions, while it is absorbed by bromine. So small a quantity as one or two per cent of alcohol may be recognized in this way. Acetone and other similar bodies present in wood-spirit, yield no ethylene.—*Ann. Chim. Phys.*, V, ix, 54, Sept. 1876. G. F. B.

7. *Synthesis of Allantoin.*—GRIMAUX, having observed that pyruvic acid in reacting upon urea generated a substance pyruvile $C_5H_8N_4O_3$, homologous with allantoin, inferred that its homologue, glyoxylic acid, by the same reaction would yield allantoin

elf. This he finds to be the fact. One part of glyoxylic acid l two parts of urea were heated to 100° for 8 or 10 hours, the ss was exhausted with four times its weight of boiling alcohol, l the residue insoluble in alcohol, was dissolved in 12 to 15 ıes its weight of boiling water. This on cooling deposited rstals, which after recrystallization appeared as brilliant hard trous prisms, giving on analysis the formula $C_4H_6N_4O_3$, and ving all the properties of allantoin. The reaction is:

$$C_2H_2O_3+(CON_2H_4)_2=C_4H_6N_4O_3+(H_2O)_2.$$

e mode of its formation proves allantoin to be a glyoxylic ıreide with the constitutional formula:



$$\begin{array}{l} CH \begin{cases} NH-CO-NH_2. \\ NH \end{cases} \\ | \qquad\qquad\quad \searrow CO \\ CO-NH \nearrow \end{array}$$

Bull. Soc. Ch., II, xxvi, 482, Dec. 1876. G. F. B.

8. *Rhodein, a new test for Aniline.*—JACQUEMIN has proposed ıew test for the presence of aniline, which is a modification of e hypochlorite test. A centigram of aniline in 500 c. c. of water, ows no reaction ordinarily with the hypochlorite of sodium. ıt if a few drops of a very dilute solution of ammonium sulphide ne drop to 30 c. c. of water) be added, a magnificent rose color developed, due to a new body which the author calls rhodein. s 4 milligrams of aniline can be detected in a liter of water, the nit of delicacy in the reaction is $\frac{1}{250000}$.—*Ann. Chim. Phys.*, , ix, 571, Dec. 1876. G. F. B.

9. *Sensitive Flames.*—Mr. R. H. RIDOUT has devised a form of rner by which great sensitiveness is attained at very low pressures, and thus the principal difficulty ordinarily experienced, of ıintaining a high and constant pressure, is avoided. A glass or etallic tube, about five inches long, and five-eighths inch diameter, is closed at one end with a perforated cork, through which des a piece of one-eighth tubing about six inches long. One d of this is either drawn out to a jet or closed in the blow-pipe me to reduce its diameter to about one-sixteenth inch, and the her end is connected to a gas supply. The outer tube is held in suitable support, and the inner tube is pushed through the cork l it nearly reaches the mouth of the outer one, and a light is then plied. It now gives a long steady flame which is easily rendered nsitive by lowering the inner tube. Several effects are described hich may be shown by it at any pressures above one-tenth inch water.

A second arrangement is figured, in which two parallel vertical bes are connected by a horizontal tube in which a drop of water placed as an index. A very slight excess of pressure is shown r the motion of the drop to one side or the other. Allowing gas flow through both tubes and lighting either jet the water will ove toward the other, showing that the effect of the combustion to obstruct the flow. Similarly it may be shown that a sensive jet produces a greater resistance when its length is shortened r a noise or musical note. This effect may also be shown whether e jet is lighted or not.—*Nature*, xv, 119. E. C. P.

10. *Theory of Luminous Flames.*—Dr. **Karl Hinmann** has published an elaborate discussion on this subject, in which he concludes that the theory of Davy must be altered, but need not be replaced by a new hypothesis. From a discussion of the work of previous observers, and a variety of experiments on the diminution and restoration of luminosity in hydrocarbon flames, and on the distance between flame and burner, he arrives at the following conclusions.

(1.) The fact that a gas-flame does not rest upon the burner, nor a candle-flame upon the wick, as also the fact that a flame never directly touches a cold body held within it, is to be explained by the cooling action exercised upon the gas by its surroundings. The combustible gases are cooled throughout a definite space below their ignition-temperature; the flame is therefore extinguished. This conclusion is opposed to that of Glochmann.

(2.) The very considerable distance noticed between the burner and the flame of a gas issuing under high pressure, or mixed with a large column of an indifferent gas, cannot be accounted for on the grounds put forward by Benevides. The production of such a distance is much rather to be traced to the cooling action of the stream of gas and of the outer air, and perhaps more especially to the fact that the velocity of the stream of gas in the neighborhood of the burner is greater than the velocity of propagation of ignition within the gas.

(3.) In order that other circumstances conditioning the effect may be removed, the velocity of propagation of ignition must be equal to that of the gas-stream at the point, situated some distance from the burner, where the flame begins.

Determination of the velocity of ignition should be made under these conditions for different gases, and since this magnitude is a function of the difference between ignition and combustion temperatures, conclusions may be drawn from such experiments regarding the relations existing between these points.

(4.) The velocity of propagation of ignition may be easily determined for solid and liquid combustible bodies; and the numbers so obtained may be regarded as comparative quantitative expressions for the liability to ignition of these substances.—*Ann. der Chemie*, clxxxi, II, 129, clxxxii, 1; *Phil. Mag.*, iii, 1. E. C. P.

11. *Influence of Pressure on Combustion.*—M. **Wartha** has observed the burning of six stearine candles in free air, and in an iron case under a pressure of 1·95 atmospheres. They burned under this pressure with a flame of 9 to 12 cm. long, and gave much smoke; their luminous power diminished, while the flame assumed a yellowish-red color. The decrease of weight after one hour of burning was found to be less than in burning in free air. This last result is opposed to the observations of Frankland, who has affirmed that the consumption of the burning material of a candle, or the like, is not perceptibly dependent on the pressure of the medium in which the combustion occurs. It is supposed that the difference of pressure in Frankland's experiments (on

Mont Blanc and at Chamouny) was not sufficiently great to give a distinct difference in consumption of the burning matter. M. Wartha further put a candle to burn under an air pump receiver, with special apertures, and, with increasing rarefaction, the flame was seen to enlarge, and its luminous power to diminish. At a pressure of 90 mm., the greatest rarefaction produced, the luminous power was quite gone, and the flame, which now assumed three-fold size, appeared to consist of three parts, an inner bluish-green cone with a violet sheath, and a weakly violet mantle. The diminution of the luminous power in this case M. Wartha explains by the fact that under less pressure less of the products of combustion are separated in the form of soot.—*Nature*, xv, 167. E. C. P.

12. *Large Induction Coil.*—Mr. WM. SPOTTISWOODE has had the largest induction-coil yet made, constructed for him by Mr. Apps. This coil, which is capable of giving sparks 42 inches long, is constructed as follows: It has two primaries, one used for long sparks which has a core consisting of a bundle of iron wires ·032 in. thick, forming a solid cylinder 44 in. long, and 3·5625 in. in diameter. Its weight is 67 lbs. The copper wire of this primary is 660 yards long, ·096 in. in diameter, has a conductivity of ·93 and a total resistance of 2·3 ohms. It contains 1,344 turns wound singly in six layers, has a total length of 42 in. with an internal diameter of 3·75 in. and an external diameter of 4·75 in. The other primary, which is intended to be used with batteries of less resistance for short, thick sparks, or for spectroscopes, is heavier than the other, the core weighing 92 lbs. and the wire 84 lbs. The latter may be so connected as to be equivalent to a wire of double or six times the cross-section of a single wire. The secondary coil consists of 280 miles of wire arranged in 341,850 turns. It forms a cylinder 37·5 in. in length, 9·5 internal and 20 inches external diameter. The total resistance is 110,200 ohms. It is wound in four sections, the diameter of the wire in the two central sections being ·0095 and in the outer ·0115 and ·0110. The increased section of the extremities is to allow for the accumulated charge that portion of the wire has to carry. The condenser required proved to be smaller than was anticipated. The size commonly employed with a 10-inch coil gave the best results. It consists of 126 sheets of tin-foil 18×8·25 in., separated by two thicknesses of varnished paper, ·0055 thick. With 5 quart cells of Grove, a spark of 28 inches was obtained, with 10, one of 35 inches, with 30 one of 37·5, and later, one, of 42 inches. As these sparks were obtained without difficulty, it appears not improbable that, if the insulation of the ends of the secondary wire be carried further than at present, a still longer spark might be obtained. The insulation is such that 70 cells have been used without injury. With the 28-inch spark a block of flint-glass three inches in thickness has been pierced. When used for vacuum tubes this coil gives illumination of extreme brilliancy

and very long duration; with 20 to 30 cells and a slow working mercury break, giving, say 80 sparks per minute, the striæ last long enough for their forward and backward motion to be perceived directly by the unassisted eye. The appearance of the striæ when viewed in a revolving mirror was unprecedentedly vivid, and this even when only two or three cells were employed.—*Phil. Mag.*, iii, 30. E. C. P.

13. *Lectures on some Recent Advances in Physical Science, with a Special Lecture on Force;* by P. G. TAIT, M.A. Second edition, revised. London, 1876. (Macmillan & Co.)—The lectures of Professor Tait, as is stated in the preface to the first edition, were delivered in the spring of 1874. They are printed in the same form in which they were given in the lecture-room, with only occasional changes; the somewhat familiar way in which the principles are presented, however, is by no means a defect in the book, but on the contrary makes it all the more interesting and readable. Of the thirteen lectures in the first edition about one-half are on the subject of the Conservation and Transformation of Energy. The clear and systematic way in which Professor Tait has developed this most important subject makes the book an invaluable one for all who would become familiar with the principles upon which modern Physical Science is based. Not the least interesting of the lectures devoted to this matter is the one in which the early history of Energy is discussed, from the laws of Newton to the experiments of Joule and Colding. The remaining six lectures are devoted to: Radiation and Absorption, the Spectrum Analysis, the Conduction of Heat, and the Structure of Matter. These subjects are treated in the same clear, logical way which characterizes the discussion of the principle of Energy. A lecture on the subject of Force has been added to the second edition of the work; it was originally delivered in September, 1876, before the British Association.

II. GEOLOGY AND MINERALOGY.

1. *Grand'eury on the Carboniferous Flora.*[*]—This remarkable memoir, though entitled the Carboniferous Flora of the Department of the Loire and of Central France, discusses the comparative distribution of the coal plants of all parts of the world, and the botanical relations of all the genera of the Coal period, so that it is quite as much a general as a local work; and it is in truth one of the most important contributions made for a long time to our knowledge of the Paleozoic Flora. One of its distinguishing characteristics is the attention given by the author to the study of plants *in situ*, and to the relation of their parts to each other, as ascertained in the beds in which they lie. The description of coal plants from mere fragments of leaves or stems, or even from

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[*] Flore Carbonifère du Departement de la Loire et du Centre de la France, par F. Cyrille Grand'eury, (Mem. Acad. Sci. France.)

detached fruits, must always be unsatisfactory, and yet this is all that has been possible to many eminent and laborious workers in this field. We need however much more than this. The paleobotanist must dig for himself, and spare no labor to trace up any plant to its leaves and fructification on the one hand, and to its roots on the other. For work of this kind, M. Grand'eury seems to have enjoyed great facilities, more especially in the sections at St. Etienne, which rival those of the South Joggins and North Sydney in Nova Scotia in their exposure of plants *in situ*, while they seem even to excel them in the preservation of minute structure. The result is that M. Grand'eury affirms with confidence many correlations of parts and structures, heretofore attested on the evidence of actual observation in the Nova Scotia sections, but which have been persistently denied by some European botanists, because not in harmony with their preconceived views.

In the strictly botanical part of the work, which extends to 348 quarto pages, with an atlas of thirty-seven plates, M. Grand'eury passes in review all the leading genera of coal plants, and more especially those which constituted the forest trees of the period. We can notice only a few of the more important points on which he touches.

Beginning with the order of *Calamariæ*, which he recognizes as belonging to the vascular Cryptogams and near to the modern *Equisetaceæ*, he admits as true genera *Calamites*, *Asterophyllites*, *Annularia*, *Equisetites* and *Sphenophyllum*. This is in accordance with the views always held by our American paleo-botanists, but contrary to the hasty statements which have sometimes been made elsewhere, that the leaves known as *Asterophyllites*, *Sphenophyllum*, etc., were those of *Calamites*, and that *Calamites* them selves are but internal casts of *Calamodendra*. On these points M. Grand'eury brings many new facts to show diversities in structure and fructification between these plants. He recognizes, however, some *Volkmanniæ*, as being fruits of *Asterophyllites*, and *Pinnulariæ* as roots of *Annularia*. The phenomena of erect stems of *Calamites* retaining their roots and other appendages, and the structure of these stems, have forced him to the same conclusion always maintained by the writer of this article, that while, as Williamson has shown in his admirable memoirs, there are calamite-like bodies which are internal casts of stems of *Calamodendra*, there are true *Calamites* of quite distinct nature. Of the rhizomes of some Calamites, their branching at the base and sides, so as to form stools or clumps, and their following up the increase of the sediment around them, by sending out branches at various heights, he has numerous examples. He denies the Calamites true leaves, and thinks that their verticillate branches and branchlets, which are sometimes though rarely preserved in Nova Scotia, were either unusual or very deciduous.

The discussion of the Ferns is full of interesting matter; but cannot be entered into here, except to state that he sides with the writer in regarding *Megaphyton* as a tree-fern with leaves in two series, and aerial roots (as restored in Acadian Geology, p. 448), and recognizes one of his French species as identical with *M. McLeayi* of Lesquereux. In the order Lycopodiaceæ he makes the *Lepidodendreæ* a separate family, including the genera *Lepidodendron* and *Lepidophloyos*. The latter is an old and natural genus of Sternberg, very much ignored in England, but which has been recognized and used by paleo-botanists in this country. Under the name *Pseudosigillaria*, he includes some stems referred by authors to *Sigillaria*, but which, on grounds connected with the nature and arrangement of the leaf-scars, he very properly associates with the *Lepidodendra*. There can be no doubt that many cases of this kind exist; though it may be doubted whether the founding of a genus for them is the best mode of disposing of such doubtful specimens. *Knorria* and *Halonia* are recognized as imperfectly preserved or aberrant *Lepidodendreæ*.

Perhaps the most remarkable part of this memoir is the great development which it gives to the group of Gymnosperms, which, as represented in the Coal formation, he divides into the orders of the *Sigillariaceæ*, the *Cordaiaceæ* and the *Calamodendraceæ* with the uncertain group of *Noeggerathiæ* As to the Sigillaria family, he merely ventures to divide the great genus *Sigillaria* into provisional sub-genera in the same manner in which this has been done by others; but he recognizes *Syringodendron* as a separate genus. He thinks this last must have had very minute leaves, and he refers to it, as its roots, certain Stigmarioid organs which he terms *Stigmariopsis*, and which differ in some particulars from the true Stigmaria roots of the *Sigillariæ*. As to the true *Sigillariæ*, he holds with Brongniart, and with Newberry and the writer in America, that they are Gymnospermous, or perhaps, more precisely, that the true *Sigillariæ* are of this rank, but that some of the species confounded with these by their similarity of external markings, may be allied to the *Lepidodendra*. He does not seem to have met with any specimens that show the advanced structures, approaching to those of the Cycads,* found in some Nova Scotian specimens, but he considers the structure of the stem exogenous, and the resemblances which it presents to *Lepidodendron* as merely depending on adaptation to a similar habitat. He has not found the fruit of Sigillaria in place, but believes that he has discovered indications of seeds borne on the bases of leaves, and he is also inclined to accept the circumstantial evidence adduced by Dr. Newberry and the writer, that the *Trigonocarpa* and similar fruits may have belonged to some species of *Sigillaria*.

The elevation of the genus *Cordaites*, hitherto very imperfectly known, to the rank of the type of an order is a feature in this memoir. In some parts of America the leaves of these plants occur in excessive abundance, beds of shale being filled with them and layers of coal apparently composed of their remains; and they range all the way from the Middle Devonian to the Permo-Carboniferous. But they are invariably found as detached leaves, and their broad thin bases give the idea of an attachment to merely herbaceous stems. These stems have not, so far as I am aware, been found in America with their structure preserved; and Corda, who alone had figured this stem from European specimens, represents it as having a slender axis of scalariform vessels resembling that of a Lycopodiaceus plant, and indeed not more developed than that of the *Psilophyton* of the Lower Devonian. M. Grand'eury reverses all this. He adduces facts which it would be impossible here even to summarize, to show that some at least of these plants were of arboreal dimensions and that they had woody stems similar to those of Conifers. He even attributes to them the wood hitherto known as *Dadoxylon*, though in this we can scarcely agree with him. They are divisible into several generic forms, as *Cordaites*, *Dory-cordaites*, *Eu-cordaites*, and *Poa-cordaites*, which it is however admitted may be very distinct from each other in structure and affinities. Their fruits were the *Cardiocarpa* and other kinds of *Carpolites*, and when borne on the plant, they constituted spikes which have been known as *Antholithes*. The material illustrative of this new order at Grand'eury's disposal has been very extensive, and his conclusions deserve careful study and attention, though one can hardly help suspecting that he has united to the ordinary *Cordaites* plants of much higher affinities.

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* Incorrectly said to resemble Conifers, which is a misapprehension, arising perhaps from the imperfect way in which they have been figured.

The *Calamodendra*, whose structure was first made out by Cotta, and which have lately been so well illustrated by Williamson, are here elevated into a family, which includes the two genera *Arthropitus* and *Calamodendron*, agreeing in having an internal jointed medullary cavity resembling a Calamite, but differing in the structure of their wood; that of *Calamodendron* consisting of alternate radiating plates of fibers without definite order and others in radiating series. The leaves of these plants have probably been confounded with those of *Asterophyllites*, and are narrow, rigid and verticillate. Williamson has shown that *Calamostachys Binneyana* and a species of *Volkmannia* have structures similar to those of *Calamodendron* and *Arthropitus*. Grand'eury believes that these may be male strobiles with pollen, and that the true fruits may be of the kinds known as *Polypterocarpus* and *Stephanospermum*.

The concluding plates of the memoir give a series of restorations of the principal arborescent plants of the Coal formation, which are all highly suggestive, and many of them fully warranted by the facts stated in the memoir. The part of the memoir devoted to the geological relations of the plants described might well merit a separate notice. It treats of the best manner of subdividing the Carboniferous System; of the characteristic plants of each stage of the system, not only in France but elsewhere; of the plants which have principally contributed to the formation of coal; and of the relations of these plants to the thickness, quantity and age of the coal-seams. There is of course also a large amount of local detail relating to the French coal-fields.

On the whole, this memoir should be welcomed by all paleontologists. It is undoubtedly most accurate and trustworthy as to the affinities of the coal plants which the author has been able to study in their various parts and organs; and in respect to all, it is most suggestive, and cannot fail to lead to clearer views of the whole subject. One conclusion which must strike every one, and on which the writer of this notice has long insisted, is that the arboreal vegetation of the Coal period must have been much more varied than has been usually supposed; and that while we have no doubt been instituting many unnecessary species for mere fragments, we have on the other hand been forcing into unnatural union very diverse forms, by trusting to merely external characters. J. W. DAWSON.

2. *Memoirs of the Geological Survey of Kentucky*, N. S. SHALER, Director. Vol. I, 334 pp. 4to. 1876.—This first volume of the publications of the Geological Survey of Kentucky, contains four Memoirs.

The first is on the Antiquity of the Caverns and Cavern life of the Ohio valley, and is by Prof. SHALER. We learn from it that in the Mississippi valley, while the limestone of the Cincinnati group contains a few true caverns, far the larger part, and the largest, occur in the Subcarboniferous limestone. In Kentucky, this limestone has an average thickness of 150 feet and the caverns are exceedingly numerous; the author states that the length of the underground channels in this rock accessible to water is many tens of thousands of miles; and he thinks it no overstatement to say that there are at least 100,000 miles of open caverns. Owing to these channels, the traveler may journey for fifty miles over many parts of this limestone region in the wet season and meet with no running water. In the history of the caverns a firm bed of limestone has often held the streams for a long period, and thus a tier of caverns has been made; and then, this bed becoming worn through, the waters have descended and commenced work at a lower level, and so successive tiers have resulted. Prof. Shaler observes that the most surprising feature in the architecture of these caverns is the existence of great "domes" or wells which often rise in a single sweep from the lowermost to the uppermost level of the caves; and which are due to a fall in the course of an underground stream that originated in the early history of the cavern. Often a "sink-hole" opening to the light begins the vertical channel. Thus vertical channels, and lofty domes, tiers of great caverns along successive levels communicating with one another by the channels and domes, with streams varying from still pools to high waterfalls and using pebbles for abrasion in the lower portions, are the principal elements of these caverns. The massiveness of the limestone favored the formation of great caverns, and this massiveness Prof. Shaler attributes to its having been formed chiefly of crinoidal remains. The great profusion of crinoids and the enormous area of the Carboniferous indicates, he remarks, a wide, warm, and comparatively shallow (the Molluscan remains being quite large) sea, its waters richly charged with carbonate of lime.

Prof. Shaler discusses at length the age of the caverns and states as his conclusion that probably "while some caverns may have existed in the Mississippi valley long before the Tertiary period, their great development, with the consequent chances of organic life finding its way into cavern conditions, is a very recent event."

The second memoir is Prof. J. A. Allen's able paper on the American Bisons, living and extinct, already noticed on page 75 of this volume.

The third is by Prof. Shaler and is the first of a series on the fossil Brachiopods of the Ohio valley. The author, in this paper, takes up the very important question of amount of variation in some of the more variable species, and presents tables of measurements, in addition to detailed remarks on the different characters and the distribution of the species. For example, under *Orthis occidentalis*, measurements of 40 specimens from a number of localities are given, including dimensions as to length and width of shell, length of hinge-line and of muscular impression, width and height of foramen, and other points. The memoir is therefore an important contribution to the subject of the variation of species. These variations are wonderfully great in many cases. Thus in the above species the proportion in length to width varies from 1 : 1·05 to 1 : 1·50. This article is illustrated by seven plates, prepared, like other plates of the volume, by the autotype process, which avoids all error of drawing; and it is stated by the author that he first bedded the specimens in white sand, thereby doing away with the shadows which make one of the difficulties in properly taking a photograph for this process.

The fourth memoir, by Mr. Lucian Carr and Prof. Shaler, treats of the prehistoric remains of Kentucky. It contains a very judicious discussion of the value of the remains in North America as a measure of time, together with other interesting descriptive and historical matter, and notes on the source of the material of the implements, and on their distribution in Kentucky. It is illustrated by seven plates, containing autotype reproductions of arrow heads, pipes and other articles.

This last paper is to be continued in the second volume of Memoirs, which volume will contain also, as announced in the Preface, the following additional memoirs: on the Fossil Corals of Kentucky, on the Fossil Brachiopods of the Ohio Valley, and on the Dynamic Geology of Kentucky, by Prof. SHALER; on the Cavern Animals of Kentucky, by A. S. PACKARD, F. A. SANBORN and others; on the Cavern-dwelling Races of Kentucky, by F. W. PUTNAM; a history of the Investigation of Cavern Animals, by Dr. H. A. HAGEN.

The Memoirs published by the Survey on purely scientific subjects, like those mentioned above, will make a series of publications distinct from chapters on economical matters. The Preface states that the Memoirs may be purchased separately or in volumes at the office of the Survey in Frankfort, Kentucky.

3. *Report of a Reconnaisance from Carroll, Montana Territory, on the Upper Missouri to the Yellowstone National Park, and return, made in the summer of* 1875; by WM. LUDLOW, Captain of Engineers, Brevet Lieut. Colonel U. S. Army, Chief Engineer Department of Dakota. Being Appendix NN of the Annual Report of the Chief of Engineers for 1876. 142 pp. 8vo. 1876.—The report of Colonel Ludlow gives excellent descriptions of the topographical features of Montana and the region beyond traversed by his expedition, with notes also on routes, cañons, the geysers of the Yellowstone Park, and many other subjects of interest.

The volume also contains a Zoological Report by GEORGE BIRD GRINNELL, which is an annotated Catalogue of Mammals and Birds, and a Geological Report by Messrs. EDWARD S. DANA and G. B. GRINNELL. The subjects treated of in the last-mentioned report are the alluvial deposits of the Upper Missouri; the Cretaceous at Carroll and beyond; the Judith Mountains, where were beds of Cretaceous age, and the trachytic "Cone Butte," a conical hill, about 3,400 feet in elevation above the level of the Missouri River, the average height of the Judith Mountains; the vicinity of the Moccasin Mountains, whose appearance "indicated that, like the Judith Mountains, they are largely trachytic;" the vicinity of Camp Lewis, where the beds were reddish clays and shale, and probably Cretaceous; the west end of the Judith Mountains, in which limestone bluffs containing Carboniferous fossils were visited; the region beyond to Camp Baker, passing over Carboniferous limestone in Musselshell Cañon, dipping 50° to 60° to the south of west, which, through an overturn, was overlaid by Lower Silurian (Primordial?) strata, and finding the central portion of the Little Belt Mountains to consist of trachyte; Camp Baker and beyond toward Fort Ellis, where occurred, besides the prevailing Miocene beds (containing remains of *Oreodon*, *Rhinoceros*, etc.), a limestone of Primordial age, affording an *Obolella*, and new species of Trilobites of the genera *Arionellus* and *Crepicephalus*, along with red shales and quartzyte of the same age; the Bridger Mountains, having Cretaceous beds on the east, next Jurassic (red bands, with Jurassic fossils), and then Carboniferous limestone at the summit, with older rocks on the west, having in places a reversed dip; the geysers of the Yellowstone Park.

The occurrence of a Miocene Lake Basin in the vicinity of Camp Baker is the subject of an article by the authors in vol. xi of this Journal (p. 126). The Cretaceous formation underlaid the prairie along nearly all the route followed. The most prevailing member was No. 4, of Meek and Hayden, or the Fort Pierre Clays. But besides this, No. 5, or the Fox Hills Group, was observed at several points, and No. 6, or the Fort Union Group, at the mouth of the Judith River, overlying No. 5, where the bones of a *Hadrosaurus* were obtained.

The new species of fossils collected are described by R. P. Whitfield, and figured on two plates. The trilobites above referred to are named by him *Crepicephalus* (*Loganellus*) *Montanensis* and *Arionellus tripunctatus*. He also describes the following new species of Jurassic age from the Bridger Mountains: *Gryphæa plano-convexa*, *Gervillia sparsalirata*, *Myalina* (*Gervillia*) *perplana;* also a new Pinna from the Carboniferous of the Musselshell, *P. Ludlovi.*

4. *The Yellowstone National Park and the Mountain regions of portions of Idaho, Nevada, Colorado and Utah.* Described by Prof. F. V. HAYDEN, Geologist-in-charge of the U. S. Government Exploring Expeditions to the Yellowstone Valley, and of the U. S. Geological and Geographical Survey of the Territories. Illustrated by chromo-lithographic reproductions of Water-color sketches by THOMAS MORAN, Artist to the Expedition of 1871. Fifteen plates in large folio, with text by Prof. Hayden. Boston. 1876. (L. Prang & Co.)—This volume of colored sketches, illustrating some of the most striking points in Rocky Mountain scenery, is magnificent in scale and beautiful in execution. Mr. Moran is well known for his fine landscapes; and it is fortunate that such a painter has been over the wonderful Yellowstone region with his pencil. The colors of the landscapes will be thought too brilliant by those who have not visited the region, and perhaps in one or two cases the artist has allowed his feelings in that exhilarating atmosphere to influence in some degree his brush. But, in other cases, that for example of the scenery along the Cañon of the Yellowstone, as we understand from one who has visited the region, the colors even fall short of the reality. Speaking of the variety and richness of tints over the rocks of that region and others adjoining, Colonel Ludlow says (in the Report noticed on page 228): "Throughout this elevated region [the Judith Basin], and more especially beyond in the Yellowstone Park, we had daily occasion to observe the marked depth and clearness of the coloring, owing, I presume, to the utter purity of the atmosphere. The colors of objects comparatively near by seemed to possess an unsurpassed richness and reality; and even on distant mountains, seventy-five or eighty miles away, while the tints were necessarily blended and their details lost, they exhibited a wonderful transparency and distinctness, undimmed by the haze and vagueness which usually obscure such objects." He thus confirms the descriptions which Dr. Hayden and others have given of the strange variety and beauty of coloring that characterize the rock-scenery of that region, and not of that alone in the Rocky Mountains. The subjects of the landscapes are the following: (1) Hot Springs of Gardiner's River, Yellowstone National Park; (2) The Great Blue Spring of the Lower Geyser Basin, Yellowstone National Park; (3) The Castle Geyser, Upper Geyser Basin; (4) Lower Yellowstone Range, seen from the Yellow-

stone Park; (5) Yellowstone Lake; (6) Tower Falls and Sulphur Mountain, Yellowstone Park; (7) Head of Yellowstone River; (8) The Grand Cañon of the Yellowstone; (9) The Towers of Tower Falls; (10) The Mountain of the Holy Cross, Colorado; (11) The Mosquito Trail, Rocky Mountains of Colorado; (12) Summit of the Sierra Nevada; (13) Great Falls of Snake River, Idaho; (14) Valley of Babbling Waters, Southern Utah; (15) The Great Salt Lake of Utah. As specimens of chromo-lithography and of artistic effect, the plates are of unusual excellence.

Prof. Hayden, having become familiar with the region of the Park through his two years of exploration there, and also with the other parts of the mountains in the course of his repeated expeditions, was well fitted to prepare the text for this book of Rocky Mountain landscapes.

5. *Report on the Geological Survey of Alabama*, for 1876; by EUGENE A. SMITH, State Geologist. 100 pp. 8vo. Montgomery, Alabama.—The work during 1876 was confined to the valley known as Roup's Valley and Jones's Valley. The valley occupies the summit of an anticlinal in the southwestern end of the Appalachian region, and has the coal basin of the Warrior on the west and that of the Cahaba on the east. The anticlinal has for the most part the beds sloping regularly outward on the two sides; but in the southwest extremity the fold has been lapped together and pushed over toward the northwest, reversing the dip, so that all the strata dip southeast.

The rocks described belong to the Lower and Upper Silurian, the Devonian and Carboniferous formations. The Upper Silurian is represented by beds of the Clinton group—the formation that in the north is noted for the presence of beds of red lenticular fossiliferous iron ore. In Alabama the same ore occurs in several beds. The strata in Tennessee constitute the Dyestone group of Professor Safford. Analyses of various iron ores and limestones are given in the Report.

6. *Annual Report of Progress and Results of the Wisconsin Geological Survey*, for the year 1876; by T. C. CHAMBERLIN, Chief Geologist. 40 pp. 8vo. Madison, Wisconsin, 1877.—This report contains a brief summary of the work done and results obtained during the year 1876. It states that "a collection of 20,000 or more fossils" has already been gathered, many of them new species, and that this part of the work is in the hands of R. S. Whitfield. Among the facts announced we learn that the copper-bearing series of Michigan, with its trap, extends nearly uninterruptedly across the northwestern part of Wisconsin; and in the bed of Nemakagon River, numerous masses of native copper have been found, associated with the trap, which apparently were not far removed from their native bed, indicating that it is a rich copper region.

Prof. Irving, one of the geologists of the Survey, reports, among other things, the existence of large quantities of kaolin in Wood and Jackson Counties.

7. *Report of the State Geologist of New Jersey*, Professor G. H. Cook, for 1876. 56 pp. 8vo.—This report states that the triangulation of the State by the Coast Survey has been continued through the year. A large part of the report is occupied with facts relating to the subject of water supply, especially for Newark and Jersey City, from the Passaic River water-shed. Analyses of the waters are given, and some effects on health from bad drainage and bad water. The average annual rain-fall deduced for all parts of New Jersey is thirty inches. Of this it is estimated, for the purpose of the calculations which follow, that forty per cent, or twelve inches, may be collected in streams and reservoirs,—which is not an over-estimate, since on the Croton water-shed it has been found that sixty per cent of the rain-fall runs off in the streams.

8. *Salt Region of Goderich, Canada.*—Prof. T. Sterry Hunt, in a recent article on this region, gives the following section and explanations.

BORING WITH DIAMOND DRILL MR. ATTRILL'S WELL, GODERICH.

	Feet.	Total.
Clay, gravel, and bowlders,	79	79
Dolomite, with a few thin limestone layers,	278	357
Limestone, with fossil corals, chert, and beds of dolomite,	273	630
Dolomite, with thin seams of gypsum,	246	876
Marls, red, green, and brown, with dolomite beds,	121	997
Rock salt; first bed,	31	1,028
Dolomite, with marls toward the base,	32	1,060
Rock salt: second bed,	25	1,085
Dolomite,	7	1,092
Rock salt; third bed,	35	1,127
Marl, with dolomite and layers of anhydrite,	80	1,207
Rock salt; fourth bed,	16	1,223
Marl and dolomite,	7	1,230
Rock salt; fifth bed,	13	1,243
Marls, soft, red and bluish, with beds of anhydrite,	136	1,379
Rock salt; sixth bed,	6	1,385
Marls, soft green and grayish, with dolomite and anhydrite,	132	1,517

From the above section it will be seen that from the top of the marls, which began at 876 feet, we have 641 feet of salt-bearing strata, including 126 feet of solid rock salt, and that the base of the series, that is to say the magnesian limestone of the Guelph formation which underlies it, was not reached. The rock salt is represented as forming six beds, but the second and third, and also the fourth and fifth, might each be looked upon as forming but a single bed, divided in two by a few feet of rock. The whole of this thickness of over six hundred feet of strata holds more or less salt, disseminated in small masses and in veins.

The salt of the different beds is not alike in purity. That of the upper one is somewhat discolored by an admixture of clay, and would need to be refined by solution; the same is true of the fourth and fifth beds, while the sixth is pure and white. The second and third, which may be considered together as one bed of sixty-seven feet of salt, including a layer of seven feet of rock, deserves more especial attention. This great mass carries at the top about one foot of colorless and transparent salt, followed by about fourteen feet of salt slightly discolored in parts by an admixture of a little clayey matter, and then by 10¾ feet of perfectly white and translucent salt of singular purity. Below this, after seven feet of rock, succeeds thirty feet additional of salt, nearly pure, but clouded in parts from the presence of a little clay.

In concluding, I may call attention to some new points in the geology of this salt deposit. By reference to the Geology of Canada (1863) and the geological map, it will be seen that Goderich is situated at the base of the Corniferous or Upper Helderberg limestone, which here rests directly upon a porous dolomite (magnesian limestone), supposed to represent the so-called water-lime beds at the summit of the Onondaga, as this salt-bearing formation has been named. The fossiliferous limestone strata known as the Lower Helderberg, which in New York are interposed between the salt formation and the Corniferous, have not, with the exception of the water-lime, been recognized in Western Ontario. The upper part of the Onondaga consists chiefly of dolomites, and the lower of marls, often with gypsum beds. Analyses of these rocks will be found in the Geology of Canada, (pages 625 and 807). Some of them yield excellent hydraulic cements. The whole thickness of this formation on the Niagara River is from 200 to 300 feet, but it increases greatly to the northwest, as shown by our section. These marls, which are mixtures of clay with magnesian carbonate of lime, are often very soft, and hence are sometimes called soapstone by the well-borers. It is hardly necessary to say that they have nothing in common with the true soapstone, or steatite, with which Mr. Gibson confounded them.

A fact of much interest to the geologist is the occurrence below nearly 300 feet of dolomite, of 273 feet of strata in which pure limestones prevail, accompanied toward the base with much white chert or hornstone. These limestones, for about 180 feet, or to a depth of 529 feet, abound in corals, chiefly species of *Favosites* like those of the Corniferous limestone. From these facts it would seem that the outer ocean, which at that time must have already contained the corals of the Corniferous period, invaded the area of the salt basin, and there formed the coralline limestones, after which it was shut out during the formation of the upper 278 feet of dolomite, when it again returned, depositing over the whole its covering of Corniferous limestone. Geologists will await with interest the result of a further study of the organic remains of this limestone, and as Mr. Attrill proposes to commence the work of sinking the shaft in the spring, an opportunity will soon be afforded. The task of opening a mine at this depth can scarcely be completed in less than two years, and may require a longer time.

9. *Glaciers in the Urals during the Glacial Era.*—It is reported by M. Poliakoff, that there are glacial striæ, scratched bowlders, and moraine deposits, on the east slope of the Urals, above the

level of the stratified sand and gravel. The glacial striæ have a southeast direction. A lower secondary ridge, the last crossed by the highway before Ekaterinburg, has many parallel ranges of immense bowlders.—*Nature*, Feb. 1.

10. ***Trilobites.***—Mr. C. D. WALCOTT, of Trenton Falls, New York, a famous place for Trenton Trilobites, has succeeded in finding many specimens that illustrate directly, or by sections, the nature of some of the interior organs of the species. He has detected in many individuals axial appendages beneath the dorsal shell. In *Ceraurus pleurexanthemus* each segment of the thorax and pygidium and the three posterior of the head have a pair beneath the axial processes. Those of the thorax and pygidium appear to be short cylindrical supports for swimming appendages or rudimentary ambulatory organs; and those of the head present an obscurely jointed structure. In the same species there are "obliquely inclined bars beneath the pleural lobes, near the union with the free pleuræ," which he regards as connected with branchial appendages." In nine of his sections he has counted 43 such appendages. The bars appear to have had a fleshy or muscular support. The greatest number of bars seen in position belonging to one appendage is fourteen; it is rare to find them in position. Longitudinal sections at the union of the pleural lobes and free pleuræ show the branchial appendages as rows of dots, varying from square to oblong in shape. In *Calymene senaria* these appendages are essentially the same as in *Ceraurus.* Numerous central longitudinal sections of *Ceraurus* show the membrane covering the visceral cavity beneath the axial lobe. *Acidaspis Trentonensis* is closely like the *Ceraurus* in the structure of its ventral surface.

The ventral surface in *Asaphus platycephalus* appears to have been strengthened by arches, which supported the double row of appendages on each side of the central axis. These are the arches which were suspected to be legs by Billings.

These notes are from a brief paper by Mr. Walcott, from the 28th Report of the New York State Museum, printed in September last, in advance of its publication.

11. *Geology and Paleontology of the Argentine Republic.* II. Paleontological part; 2nd division, on the Rhetian plants and animal remains of the Provinces of La Rioja, San Juan, and Mendoza, by Dr. H. B. GEINITZ. 16 pp. 4to, with two plates.—The species here described by Dr. Geinitz are the fish, *Semionotus Mendozaensis* Gein., the Crustacean, *Estheria Mangaliensis* Jones, a species first described from Mangali of Nágpur in Central India; and among the plants there are the Ferns, *Thinnfeldia crassinervis* Gein., *Th.? tenuinervis* Gein., *Pachypteris Stelzneriana* Gein., *Otopteris Argentinica* Gein., *Hymenophyllites Mendozaensis* Gein., *Baiera tæniata* Braun, *Pecopteris tenuis* Schouw, a species described originally from I. Bornholm, and from Whitby, England, *Tæniopteris Mareyesiaca* Gein.; the Cycad, *Pterophyllum*

Oeynhausianum Göpp., a European species, and the Conifer, *Palissya Brauni* Endl. var. *minor*, Gein.

12. *Mémoire sur les Caractères Minéralogiques et Stratigraphiques des Roches dites Plutoniennes de la Belgique et de l'Ardenne Française*, par MM. Ch. De la Vallée Poussin et A. Renard. 264 pp. 4to, with nine plates, six of them containing colored figures of thin sections. A detailed account of the rocks referred to, based largely on the study of their sections. In the quartziferous dioryte of Quenast, the authors distinguished cubic crystals in the liquid filling minute cavities in the quartz, and proved the crystals to be chloride of sodium or common salt.

13. *Note on the new localities of the Columbic acid minerals, and two new Columbates;* by J. Lawrence Smith.—The locality near Marion, North Carolina, is now well known, as furnishing large and fine specimens of Samarskite. It was doubted by some mineralogists whether or not it was true Samarskite. I have been able by chemical analysis to establish beyond all doubt that it is a very fine type of this rare mineral (the cause of the doubt I will refer to another time), confirming Mr. E. S. Dana's conclusion, based on its crystallographic character. In studying the mineral, I found associated with it three other columbates—one of them already known, viz., Euxenite, and two new ones. One is in the form of a very characteristic mamillary concretion, and contains sixteen per cent of water. The other is found massive, and also in regular octahedrons, of which a few have been found; it resembles somewhat pyrochlore, but differs from it both by its chemical and physical characteristics, its specific gravity being 4·85. The latter mineral I saw about eight months ago, in the hands of Mr. J. Price Ralston, and then supposed it was new. He had sent a specimen to Mr. E. S. Dana, who gives some of its characters in connection with his crystallograpic description of Samarskite, and refers it with a query to microlite. Since then Mr. Ralston has kindly sent me his crystals, and I have now made out its nature thoroughly. The analysis of it will appear in a forthcoming paper on the American columbates.

In addition to the above, I have discovered embedded in the beautiful crystals of Amazon stone, from Colorado, very small, perfect crystals of columbite.

14. *Bulletin of the Bussey Institution, Jamaica Plain, Boston, Mass.* Vol. ii, part I. 80 pp. 8vo. 1877.—Among the papers in this valuable bulletin there are the following by Prof. F. H. Storer: on the amounts of potash and phosphoric acid in several kinds of rocks; on the agricultural value of spent dye-woods and tan; on the composition of buck-wheat straw; on the fertilizing power of roasted leather; notes of experiments in which buckwheat plants were watered with solutions of peat in alkalies.

From the first, treating of the presence of *Phosphates and Potash in Rocks*, we learn that seven granites, all from eastern Massachusetts, excepting one from the base of Monadnock, New Hampshire, afforded 2·587 to 7·434 p. c. of potash, and 0·058 to 1·191 of phosphoric acid.

	P_2O_5	K_2O
tes, eastern Massachusetts	1·407–5·241	0·042–0·066
; from Dracut	4·356	0·287
ue slate from Somerville	3·875–3·913	0·085
"	1·294	0·098
m "Milk Row Quarry"	0·303	0·444
West Dedham	1·007	0·194
c, with streaks of feldspar, West Dedham	5·035	0·053
l, Essex, Mass.	2·384	0·051
Provincetown, Mass.	0·613	0·050
bed near the Bussey Institution	0·891	0·035
cshire sand used for glass making	0·448–0·630	0–0·021

eights on Long Island.—The following facts are con- in a letter to Professor James D. Dana, from Mr. E. ·., of Brooklyn, giving the elevation and position of some incipal hills upon Long Island. The range of hills which vith some interruptions through a considerable portion of ınd, varies from 150 to 384 feet above tide, and is of great ıl interest. They constitute a prominent feature of the minal moraine of the ice sheet upon this part of the ocean ınd afford, as I have elsewhere shown, data by which cillations of the coast may be determined.* Indeed, it is :esence and position of beds of modified drift upon these . along their slopes, that the extent of subsidence since der drift was deposited can be made out.

ıights given are in part from the manuscript records of ler, kindly furnished by the Coast Survey office. Others measurements made by the writer and others. In the :e vicinity of some of the hills whose heights are given s, nearly as high, forming groups, as West Hills and Dix ups in Suffolk County. With the heights is given the of each locality from the City Hall in New York, as laid the Map of Long Island. Beginning at the extreme nd of the island we have:

	Elevation.	Distance.
ık Point,	85 feet.	113 miles.
ɔnd Hill,	194 "	108 "
gue "	135 "	102 "
nsett "	161 "	98 "
ɔck "	140 "	80 "
's " (near Riverhead),	293 "	68 "
's " (South of Coram),	340 "	55 "
Iills, (High Hill Field, known as Jane's Hill,[1]	354½ "	31 "
's Hill, (Wheatly),[2]	380 "	22 "
ıry Hill,[4]	260 "	22 "
tead Harbor Hill,[3]	384 "	20 "
I. Clark's Hill, (Manhasset),[4]	326 "	16 "
ı Hill, " [4]	332 "	16 "
ct Hill, (Brooklyn),	194 "	

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by Coast Survey 383 feet. I found it by aneroid to be scarcely more ɛet. A. J. Spooner, Esq., in his memoir of the Hon. Silas Wood, late of , says, "He (Mr. Wood), had the elevation of Oakley's High Hill Field ctober, 1825, by Mr. Abel Ketcham, an accurate surveyor, who deter- height to be 354½ feet above the water level of the Sound." The

Journal for March, 1877. Popular Science Monthly, Feb., 1877.
n U. S. Coast Survey.

survey he states was recorded in the Town Records of Huntington. It is possible that in transcribing, 353 feet may have been mistaken for 383 feet.

[2] The heights of this great mound of unmodified drift is not satisfactorily determined. The height given is nearly correct.

[3] Measured from half-tide level by Hon. Stephen Tabor, of Roslyn.

[4] Heights determined by George B. Brainerd, Esq., Engineer in the Brooklyn Water Department, and by the writer.

From the hills mentioned, and from others of the range, extensive views may be had, and the contour of the island throughout its entire breadth studied to great advantage. A striking feature observed is the vast, nearly level plain which extends from the foot of the hills southward to the Great South Bay. At a distance of from one to two miles from the foot of the hills the following elevations above tide were determined by early surveys, for the Long Island Railroad. I quote from Prime's History as follows:

1. Bedford, (in the city of Brooklyn),	73	feet.
2. Jamaica,	40	"
3. Mineola,	103	"
4. Hicksville,	142	"
5. Farmingdale,	63	"
6. Suffolk Station,	90	"
7. Medford.	82	"
8. Riverhead,	32	"
9. Southold,	40	"

The average elevation of the "Plains," so-called, along the line of the railroad, is therefore about 70 feet. Northward of the hills, extending to the Sound, the surface is uneven, and no general topographical survey of it has been made. We have, however, the elevations at several points. Some of these exceed 200 feet, and an estimate of the general elevation of the surface formerly made, of from 130 to 150 feet, is not far from correct.

III. Botany and Zoology.

1. *Dextrorse and Sinistrorse:* Which is right and which is left, as applied to twining, overlapping in flower-buds, and course of the spiral in phyllotaxis? There are two opposite ways of regarding it; according to one a hop-vine turns to the left, according to the other, to the right; and authorities and usage are divided. Uniformity is most desirable, and this seemed to be secured when the view taken by Linnæus was adopted by the elder DeCandolle and followed "by Mohl, Palm, A. Braun," Alph. DeCandolle, "and other observers." Still the opposite view is now coming in, and if it should prevail against such an array of authority it must be because it proves more convenient and sensible in practice. From an article in the Gardeners' Chronicle for January 13, last, we learn that the subject was taken up by M. Alph. DeCandolle (whose judgment would always be much deferred to) at a recent meeting of the Botanical Society of France. As we have seen no report at first hand, we make the following extract from the Gardeners' Chronicle. It purports to represent the view and the reasoning of another excellent botanist, A. Braun:

"Professor Braun remarks that the best way to follow in determining the direction of the spiral is to follow the indication of the object itself. It is the animal or plant which ascends or descends, or goes to the right or the left. Again, in the case of an animal the position of an observer is of no consequence. We can distinguish the right and left sides of the animal, not from our position in relation to it, but according to the conformation of the animal itself. The animal cannot speak to us and tell us which is his left and which his right flank, but we, speaking animals, are able to do so."

That is to say, the animal—or rather the vertebrate animal—having front and back, has consequently a right side and a left. But the stem of a plant has none of these relations, neither front nor back, therefore neither right nor left. When we predicate right or left of a stem, or of a flower-bud, obviously it is the right or left of a viewing person. DeCandolle's illustrations concede this, although that of Braun ignores the distinction. When "in the case of a river the universal practice is to call the left bank that to the left hand of an observer supposed to be following the natural onward course of the stream," this is because it is more natural to go with the current, and it is the traveler's not the river's, right that is designated. So the difference between the two schools in the case in hand resolves itself into the position which the observer is supposed to occupy. "M. DeCandolle," following Linnæus, "supposes himself in the center of the coil" in the case of a twining stem. Bentham and Darwin suppose themselves on the outside,—a more feasible position, as it seems to us, and its naturalness is recognized by the mechanic, who everywhere regards the common screw as a right handed screw, and that in which the spiral rises towards the left of the outside observer as a left handed screw. If this is the natural way to look at a screw, why not the natural way to look at a twisted stem, or a coiled stem? Wherefore we conclude that this way of regarding the case, as practiced by Bentham and Darwin, is coming into vogue in spite of Linnæan authority, on account of its intrinsic reasonableness and convenience. A. G.

2. *A Botanical Necrology* of 1876.—The list is headed by the distinguished name of

ADOLPHE THEODORE BRONGNIART, who died in January, 1876, just when he had completed the 75th year of his age. The long list of his publications began in the year 1820, and was interrupted only at his decease, his latest communications to the Academy of Sciences and to the Botanical Society of France being in the year 1875. Some interesting investigations in fossil botany, which were in hand when he succumbed, are left unfinished. The Bulletin of the Botanical Society of France, under date of Feb. 25, contains the touching and instructive funeral discourses pronounced by his colleagues Duchartre, Decaisne, Bureau, Jourdain, Chatin, and others.

JOHN JOSEPH BENNETT, the associate of Robert Brown in all the latter part of his life, and his successor as keeper of the Herbaria of the British Museum, up to the close of the year 1870, was born January 8, 1801, and died Feb. 29, 1876. He was one of the best and most amiable of men, one of the most learned and the most modest; and his writings, like those of his master, Robert Brown, have an importance greatly exceeding their number and pretension. There is a biographical notice in Trimen's Journal of Botany, with a good portrait.

CHRISTIAN GOTTFRIED EHRENBERG, whose death, on the 22d of June, at the age of 82, was duly announced in this Journal, must also be counted among the botanists, against his early convictions as respects his life-long work upon the Diatomaceæ, and some of his earliest papers relate to Phanerogamic Botany. His earliest botanical paper bears the date of 1820.

LEOPOLD FÜCKEL, the Mycologist, author of the classical Fungi Rhenani Exsiccati, died at Vienna, May 8, 1876.

EDWARD NEWMAN, who died, near London, June 12, 1876, at the age of 75, was better known as a zoologist than as a botanist, but is to be remembered among the botanists and amateurs for his well-known History of British Ferns, which has passed through four editions, and as the principal editor of the Phytologist, from 1841 to 1854.

JOSEPH CARSON, M.D., long the professor of Materia Medica in the University of Pennsylvania, died at Philadelphia, December 30, at the age of 68. He was an active general botanist in his earlier years. Later his attention in this line was mainly directed to the history of medicinal plants, especially those of America. In lore of this kind he had no superior, at least since the premature death of Hanbury, and in this country he leaves no equal. He was an excellent teacher, a firm friend, and a most estimable man. Dr. Carson was one of a considerable circle of botanists, whose acquaintance the present writer made at Philadelphia more than forty years ago, of which there is now only one survivor, and he no longer a resident of Philadelphia. A good notice of Dr. Carson was contributed to the January number of the Bulletin of the Torrey Botanical Club, by its worthy President. In it the portrait of F. André Michaux, which has for many years adorned Dr. Carson's study, is referred to as "so far as known, the only likeness of that botanist extant." It may be worth while to record, that the writer of the present notice is the possessor of a daguerreotype likeness of the younger Michaux, taken in Paris a year or two before his death, and from which a photographic copy has subsequently been taken.

WILHELM HOFMEISTER, the distinguished vegetable anatomist, successor of Von Mohl in the chair of Botany at Tübingen, as we learn, died on the 12th of January last. A. G.

3. *Mistletoe* (*Viscum album* Linn.)—MM. Grandeau and Bouton, in chemical examinations of the mistletoe, find that the stem differs essentially in composition from that of the tree on which it grows, and varies with the species; it contains much more potash and phosphoric acid than its supporting tree and much less lime,

and seems to live on the tree like a plant on its soil.—*Comptes Rendus*, Jan., 1877; *Nature*, Jan. 25, 288.

4. *Observations on Rhizopods.*—Prof. Leidy stated that last July, in the sphagnum swamps of Tobyhanna, Pocono Mt., Monroe Co., Pa., he noticed an abundance of a Rhizopod which he thought he had not previously seen, and which he at first supposed to be an undescribed species, but which he now viewed as a variety of *Hyalosphenia ligata.* From this, as previously described, it differs in the test being of a pale sienna color, and perhaps of greater thickness, but otherwise is like it. The test is compressed pyriform, with the length and breadth nearly or about equal, and the thickness one-half. The lateral orders are obtusely rounded. The mouth is transversely oval. The sarcode is colorless, and attached to the inside of the test by diverging threads. The pseudopods are usually from two to three. Measurements, ·08 mm. long and broad, and ·036 thick, with the mouth ·02 broad and ·008. Others varied from ·06 long and ·08 broad, to ·092 long by ·064 broad.

In observing the Pocono variety of *Hyalosphenia ligata*, and the beautiful and well-marked species *Hyalosphenia papilio*, he detected an important point of structure which previously had escaped his notice. In the active condition of these, and other Difflugians, they are seen with one or more pseudopods extended from the mouth of the test, to the margin of which the sarcode is attached, as well as by diverging threads to various points of the interior of the test. The interval between the body of the sarcode and the interior of the test is occupied with water. The extent of the interval increases with the increase in number and extent of protrusion of the pseudopods, and also varies according to the degree of emptiness or repletion with food of the sarcode body. When the pseudopods are withdrawn into the mouth of the test, the mass of the sarcode expands in a corresponding ratio, and the threads of attachment to the inside of the test contract in length. The intervening water appears to be displaced through small apertures of the lateral borders and fundus of the test, which exist in numbers usually from two to half a dozen or more.

While speaking of Rhizopods, he would ask the attention of the Academy to some remarks on recent observations on the habits of several species of Amœba.

One of the species of Amœba which he had most commonly seen, he took to be the *Amœba verrucosa* of Ehrenberg, with which the *A. natans* of Perty, and the *A. terricola* of Greef, appeared to him to be synonymous. This species he had found in many places: in the crevices of the brick pavement in the yard attached to his residence, in brick ponds, in the ooze of the rocky shores of the Schuylkill River, in sphagnum swamps, in marsh mud, etc. It is remarkable for its sluggish character; and in appearance reminds one of a little pile of epithelial scales, or fragment of dandruff from the head. Appearing quadrately oval or rounded, transparent, and more or less wrinkled, or marked with delicate wavy lines; the pseudopods rise in short obtuse mammillary eminences or wave-like ridges, the summits of which are composed of transparent ectosarc, while the central portion of the body is occupied by a thin, pale, diffused, and finely granular entosarc. This contains one or more vesicles, usually one, which very slowly enlarges, and then less slowly collapses. In addition, as part of the structure, an oval granular nucleus is sometimes visible. The food contents generally appear not to be abundant, and often the creature appears to be empty of food altogether. The character of its food is the same as with other species of Amœba. It not unfrequently feeds on Difflugians. In a specimen from sphagnum water, from Vineland, N. J., last August, he observed an individual, about the $\frac{1}{10}$ of a millimeter, containing a Difflugia and a Trinema together. As observed by him, the species ranges from $\frac{1}{25}$ to $\frac{1}{6}$ of a millimeter in diameter.

On the morning of August 27, from some mud adhering to the roots of *Sparganium*, obtained the day previously in a nearly dried-up marsh, at Bristol, Pa., he obtained a drop of material for examination with the microscope. After a few moments he observed an *Amœba verrucosa*, nearly motionless, empty of food, with a large central contractile vesicle, and measuring $\frac{1}{25}$ of a millimeter in diameter. Within a short distance of it, and moving directly toward it, was another and more active Amœba, the species of which he was not positive. It was, perhaps, the one described by Dujardin as *A. limax*, by which name, for the present purpose, it may be called. As first noticed, this Amœba was limaciform, $\frac{1}{8}$ of a millimeter long, with a number of conical pseudopods projecting from the front broader end, which was $\frac{1}{16}$ of a mm. wide. The creature contained a number of spherical food vacuoles with sienna-colored contents, a large diatome filled with endochrome, besides several clear vacuoles, a posterior contractile vesicle, and the usual granular entosarc. The *A. limax* approached and came into contact with the motionless *A. verrucosa.* Moving to the right, it left a long finger-like pseudopod curved around its lower half, and then extended a similar one around the upper half until it met the first pseudopod. After a few moments the ends of the two pseudopods actually became connate (the second time he had observed this phenomenon), and the *A. verrucosa* was inclosed in the embrace of the *A. limax.* The latter assumed a perfectly circular outline, and after awhile a uniformly smooth surface; but the central contractile vesicle remained in the same condition, nor did he once observe it enlarge or collapse. The *A. limax* now moved away with its new capture, and after a short time what had been the head end contracted, became wrinkled and villous in appearance, while from what had been the tail end a number (ten) of conical pseudopods projected. The *A. verrucosa* assumed an oval form, and the contractile vesicle became indistinct, without collapsing. Moving on, the *A. limax* became more slug-like in shape, measuring about $\frac{1}{4}$ mm. long, by $\frac{1}{28}$ mm. broad. The *A. verrucosa* now appeared inclosed in a large oval clear vacuole, was constricted so as to be gourd-shaped, and had lost all traces of its contractile vesicle. Subsequently, the *A. verrucosa* was doubled upon itself; and at this period, the *A. limax* discharged from one side of the tail end, the siliceous case of the diatome, which now contained only a shrivelled cord of endochrome. Later the *A. verrucosa* was broken up into five spherical granular balls, and these gradually became obscured and apparently diffused among the granular contents of the entosarc of the *A. limax.* At one moment the five granular balls derived from the *A. verrucosa* appeared to be contained in three vacuoles, and the *A. limax* had a more contracted and radiate form, and then measured $\frac{1}{12}$ mm. in diameter.

The observation, from the time of the seizure of the *A. verrucosa* to its digestion, or disappearance among the granular matter of the entosarc of the *A. limax*, occupied seven hours.

From naked Amœbæ, the test-protected Rhizopods were no doubt evolved, and it is a curious sight to observe them swallowed, home and all, to be digested out of their home, just as the contents of diatomes are digested. It was also interesting to observe the cannibal Amœba swallowing another, and appropriating its structure to its own, just as we might do a piece of flesh, completely, without there being any excrementitious matter to be voided.—*Proc. Acad. Nat. Sci. Philad.*, 1876, 197.

5. *Habits of Formica rufa.*—Mr. McCook, speaking of the habits of *Formica rufa*, stated that the ants descending the tree-paths, with abdomens swollen with honey dew (called by him *Repletes*), were arrested at the foot of the trees by workers from the hill seeking food. Galleries communicating with the hill, opened at these points, around and in which numbers of ants were huddled engaged in drawing or bestowing rations of honey-dew. Similar commissary stations were found under the stones near by. The replete reared upon her hind legs, and placed her mouth to the mouth of the pensioner, who assumed the same rampant posture. Frequently two, sometimes three pensioners were thus fed at once by one replete. Apparently the workers engaged in building at the hill and galleries had thus resorted to these feeding places to obtain ordinary food, in the same manner that queens, males, and young ants receive it, viz: by disgorgement from the abdomens of repletes. The latter commonly yielded the honey-dew complacently, but sometimes were seized and arrested by the pensioners, occasionally with great vigor.

A number of experiments were described leading to the conclusion that there was complete amity between the ants of a large portion of the field, embracing some 1600 hills and countless millions of creatures. Insects from hills widely separated always fraternized completely when transferred. A number of ants collected from various hills fraternized in an artificial nest, harmoniously building galleries and caring for the cocoons.

It was found that ants immersed in water when replaced upon the hills were invariably attacked as enemies; the assailants, being immersed, were themselves in turn assaulted. A number of experiments were made which indicated that the bath had temporarily destroyed the peculiar odor or other property by which the insects recognized their fellows.

The variety of *F. rufa* which had colonized in vast numbers on the cliff at Rockland opposite the steamboat landing, as observed for the last three summers, were found that morning to have abandoned the place. No trace of them could be seen in the vicinity. The crowds of human beings who occupied the spot during the late International regatta had evidently dispersed the republic.—*Proc. Acad. Nat. Sci. Philad.*, 1876, p. 200.

6. *The Rhynchophora of America, north of Mexico;* by JOHN L. LECONTE, assisted by GEORGE H. HORN. 456 pp. 8vo, constituting vol. xv (December, 1876) of the Proceedings of the American Philosophical Society.

7. *A new Echidna (Tachyglossus) from New Guinea.*—The new species has its rostrum half longer (the length about 6·4 inches) than either that of the species from southeastern Australia or that from Tasmania. It is named *Tachyglossus Bruijnii* by Peters and Doria in a paper published at Genoa.—*Nature*, Jan. 18.

IV. ASTRONOMY.

1. *A New Planet;* C. H. F. PETERS. (From letters of January 22 and 31, dated Litchfield Observatory of Hamilton College, Clinton, N. Y.)—On the 17th instant, I saw a planet unknown to me in the position approximately of $8^h\ 34^m\ 55^s$ of R. A., and $+17°\ 52{\cdot}7'$ Decl.; but the weather thickened so that an accurate position could not be obtained before last night, when at ten o'clock the stranger was in $8^h\ 30^m\ 20^s$ of R. A., and $+17°\ 42'$ Decl. (the reductions having not yet been fully completed). Hence the motion was in four days $4^m\ 35^s$ and $-11'$. The magnitude I estimated the 11th.—(Letter of Jan. 22.)

From LeVerrier's *Bulletin International* of January 12, just received, I see that the planet I gave you notice of on the 22d instant, had already been found at Toulouse, on January 10. But through neglect somewhere, the usual notification by telegraph,—as has been customary between European and American astronomers during recent years, and for which the Atlantic Cable Company has made a liberal concession,—has not reached us.

I communicate two more observations,—all that weather and moonlight have permitted since the 21st,—each from ten comparisons with stars well determined:

1877.	Mean time.	α(170).	δ(170).
Jan. 23.	$9^h\ 50^m\ 45^s$	$8^h\ 27^m\ 59{\cdot}40^s$	$+17°\ 35'\ 24{\cdot}8''$
" 26.	$11^h\ 48^m\ 51^s$	$8^h\ 24^m\ 23{\cdot}42^s$	$+17°\ 26'\ 15{\cdot}0''$

—(Letter of January 31.)

2. *Instruments and Publications of the U. S. Naval Observatory.* Rear Admiral C. H. DAVIS, Superintendent. Washington, 1845–1876. Published by authority of the Hon. Secretary of the

Navy. 44 pp. 4to, with six plates.—After a brief account of the founding of the Observatory, its library, and its position, the several instruments are described, the Mural circle and Transit instrument mounted in 1844, the Prime Vertical Transit Instrument and 9·6 inch Equatorial mounted in 1845, the Transit circle mounted in 1865, and the 26-inch Equatorial mounted in 1873, and to the descriptions are added heliotype representations of the instruments.

3. *Note of the recent fall of three Meteoric Stones, in Indiana, Missouri, and Kentucky;* by J. LAWRENCE SMITH, Louisville, Ky. (Communicated.)—Three meteorites were seen to fall inside of a comparatively small region of the United States within the space of about one month. These falls were accompanied by some interesting phenomena, and in the case of the fall of the twenty-first of December, the appearance of the bolide from which it came was truly magnificent, and was seen over a large tract of country, from west to east. My object at the present time is simply to announce these falls, reserving for a future communication fuller details, when I have completed their chemical and mineralogical examinations. I will then call attention to an interesting aërolitic belt in this country, in which a very large number of meteorites have fallen during the past sixteen years.

No. 1, fell on December twenty-first, 1876, at 8^h, 40^m, P. M. This remarkable bolide was seen to pass over the States of Kansas, Missouri, Illinois, Indiana and Ohio—a distance from east to west of about 800 miles. It burst into numerous fragments during its passage, producing "a flock of brilliant balls, chasing each other across the sky, the number being variously estimated from twenty to one hundred." The passage of it is described in this Journal for February, 1877. A piece from this bolide, of a few ounces in weight, has been found near Rochester, in Indiana, latitude 41° 8′, longitude 86° 12′, and I have received a portion of it for examination.*

No. 2. On January third, 1877, at sunrise, in Warren County, Missouri, latitude 38° 50′, longitude 91° 10′, the usual phenomena accompanying the falls of meteorites attracted the attention of several observers, who saw the stone strike the branch of a tree, (which it broke), then fall to the ground, penetrating it slightly, and melting the snow that lay on its frozen surface. It was picked up immediately after, and a portion of it has been sent to me for examination.

No. 3. On January twenty-third, 1877, in the afternoon, a few miles north of Cyntheana, Ky., latitude 38° 25′, longitude 84° 15′, a meteoric stone was seen to fall, accompanied by great atmospheric disturbance, penetrating the ground to the depth of thirteen inches. There was an observer on the ground near the spot where it fell, and he immediately dug it up. It weighs about fifteen pounds.

Louisville, Ky., February 6.

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* This is the meteorite which is the subject of Professor C. U. Shepard's article, on page 207.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Topographical Survey of the State of New York.*—As announced in a former volume of this Journal, this survey was commenced last year, under Mr. James T. Gardner as Director. This event, which had been recommended by the Geographical Society of New York, appeared to be a promise that topographical surveys were now to be carried on over the country which would soon put the nation on a level with those of Europe in its maps, and in its knowledge of its own industrial resources. But the recent recommendation of the Governor of New York threatens a stop to the work, and a still longer continuance of faulty maps, uncertain lines of roads and boundaries, unknown water-privileges and drainage areas, and general topographical ignorance. A petition in favor of the survey has been addressed to the legislature by the New York Geographical Society, and the Faculties of Columbia College, the Polytechnic Institute of Troy, and other institutions, and the editors of this Journal hereby send their petition to the same effect.

2. *Tour of the Great Lakes: Summer School of Natural History.*—Professor T. B. Comstock of Cornell University, proposes "if sufficient encouragement be given prior to May 1," to charter a steamer for a period of four to six weeks, and start from Buffalo or Cleveland, about July 5th, on a tour along the shores of Lakes Erie, Huron and Superior, and possibly also Lake Michigan. Competent instructors in geology and botany are to be engaged, and lectures from specialists are promised. The prospectus states that the expenses will not exceed $125 for thirty days and $3.50 for each additional day. The trip will be limited to thirty days unless a majority vote of the pupils decides otherwise.

3. *Elements of Physics, or Natural Philosophy;* by NEIL ARNOTT, M D., LL.D., F.R.S. Seventh edition. Edited by Alexander Bain, LL.D., and Alfred Swaine Taylor, M.D., F.R.S. 873 pp. 8vo. New York, 1877. (D. Appleton & Co)—The first edition of the "Elements of Physics" by Dr. Arnott appeared in 1827, and within four years from that time five large editions were called for. The author himself died in March, 1874, but his work still lives, with the same popularity which it had on its first appearance. Its especial excellence lies in its clearness of style and fullness of illustration. Each new principle is enforced by many familiar examples, which remove the difficulties that the student would be likely to find in understanding it if stated in a dry formal way. The book consequently is throughout eminently interesting and readable, even for those who have no special knowledge of the science. Under the editorship of Professor Bain and Dr. Taylor, the new edition of the work is made to include the recent advances in the science.

4. *Metric System. Metric Bulletin.*—This bulletin, the official Journal of the "American Metric Bureau," is issued in Boston, from 13 Tremont Place. Nos. 3 and 4 were issued together, as the number for September and October, 1876.

In December, a report was published by the Boston Society of Civil Engineers, from "the Standing Committee on the Metric System of Weights and Measures," urging the general adoption of the system and giving various facts indicating the great progress which has been made in the country toward that end.

It is expected that the metric system of weights will soon be exclusively used in the Post Office Department of the country; and hoped that it may be introduced into the Custom House, as has been urged for some time by the American Metrological Society. These are the best first steps in the change; and when once carried out, and teachers do their duty in common schools, the change may become general. Compulsory for the people at large it cannot be at present.

5. *Illinois Museum of Natural History.* Bulletin No. 1. 76 pp. 8vo.—This first Bulletin, devoted to the Natural History of Illinois, contains the following papers: A list of Illinois Crustacea, by S. A. Forbes; The tree in Winter, by F. Brendel; Sodic Pinate as a test for lime, by J. A. Sewall; partial catalogue of the fishes of Illinois, by E. W. Nelson; on parasitic Fungi, by T. J. Burrill; list of the Orthoptera of Illinois, by Cyrus Thomas.

6. *Huronian rocks of the Lake Superior region described by Major Brooks.*—Thin sections of these rocks, for microscopic examination, are prepared by R. Fuess, of Berlin, and may be obtained at a small price. The collection contains thirty sections.

7. *Third Annual Report of the Commissioner of Agriculture of the State of Georgia*, for 1876.—Besides various facts of local importance, this report gives analyses of marls from different beds, and also of other mineral materials, by P. H. Mell, chemist.

8. *The Applications of Physical Forces;* by AMEDÉE GUILLEMIN. Translated from the French by Mrs. Norman Lockyer, and edited, with additions, and notes, by J. Norman Lockyer, F.R.S. 742 pp. Roy. 8vo, with colored plates and illustrations. London, 1877. (Macmillan & Co.)—This work on physics with special reference to its applications, is an example of science well simplified and popularized. The editorship of Mr. Lockyer is a sufficient warrant that the science is good. The style of publication is seldom equalled for beauty in scientific works, the typography, paper, and very numerous illustrations being the best that art can accomplish. It treats, under "applications of the laws of weight," of levels, pendulums, balances, hydraulic presses, fountains, pumps, fire-engines, atmospheric railways, compressed-air railways, balloons, etc., etc.; and similarly looks to the practical under applications of the phenomena and laws of sound, of light, of heat, of magnetism and electricity. Under heat, the art of warming is first treated historically and practically; then practical points arising from the conductibility of heat, burning glasses, compensating pendulums, distillation, artificial preparation of ice, steam engines of various kinds, steam navigation, the locomotive, hot-air and gas-engines. The work, therefore, is not only attractive in appearance, but also of real value.

Science Lectures at South Kensington. A valuable series of lectures, published separately, including: *Sound and Music*, by Dr. W. H. Stone; *Photography*, by Captain Abney, R.E., F.R.S.; *Kinematic Models*, by Prof. Kennedy, C.E. London and New York; *Outlines of Field-Geology*, by Prof. Geikie; *The absorption of light and the colors of Natural bodies*, by Prof. Stokes. 1875, 1877. (Macmillan & Co.)

Manchester Science Lectures for the People: *What the Earth is composed of*, three lectures by Professor Roscoe, F.R.S. London and New York. 1876. (Macmillan & Co.)

OBITUARY.

Rear Admiral Charles Henry Davis died on the eighteenth of February, at the age of seventy years, having been born in Boston, January 16, 1807. Admiral Davis was Superintendent of the Naval Observatory at Washington at the time of his decease, and also one of the members of the Light House Board. He became Superintendent of the "American Nautical Almanac" in 1859, the foundation of which was directly owing to his efforts. From 1842 to 1849 he was an Assistant in the Coast Survey; and one result of his labors, of great value to navigation, was the discovery of the "New South Shoal" in the track of vessels sailing from New York to Europe; and another was the publication of a "Memoir upon the Geological action of the tidal and other currents of the ocean, and the Law of deposit of the flood tide," prepared after having made a special study along the Atlantic coast of the laws of tidal action. He was the author also of several able articles on astronomy and geodesy, and published in 1858 a translation of Gauss's "Theoria Motus Corporum Cœlestium."

Rear Admiral Charles Wilkes died on the eighth of February, in the seventy-seventh year of his age. Admiral Wilkes, then a Captain, commanded the United States Exploring Expedition around the world during the years 1838 to 1842, and published, after its return, a narrative of the expedition in five volumes, a hydrographic atlas, containing the maps from the various surveys of the expedition (among which are many of coral islands), and a meteorological volume. He was a bold, daring explorer, a man of strong will and great energy, sure to accomplish whatever he undertook. His sailing up Port Jackson, the port of Sydney, New South Wales, an intricate narrow bay, seven miles in length, one dark night in November, 1839, without pilot, in company with the Peacock, the other sloop of war of the expedition, picking his way along with the lead and chart, and coming to anchor quietly among the shipping of that harbor without arousing a suspicion of the foreign invasion in progress, was one of his daring feats.

Alfred Smee, the inventor of "Smee's Battery," for which he received the gold medal of the Society of Arts, and the author of works on electro-metallurgy, electro-biology, and other subjects, died on the 11th of January, in his 59th year. He was elected a Fellow of the Royal Society at the early age of twenty-one, and, among his many offices, was Surgeon to the Bank of England.—*Nature*, Jan. 25.

Professor J. C. Poggendorff, editor of the Annalen der Physik und Chemie since January, 1824, and long Professor in the University at Berlin, died the last week of January, in his eighty-first year.

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[THIRD SERIES.]

ART. XXVI.—*Note on the Sensation of Color;* by C. S. PEIRCE.

IT may, perhaps, be worth while to notice a few consequences of three theories concerning color which are usually regarded with some favor.

First hypothesis.—The appearance of every mixture of lights depends solely on the appearances of the constituents, without distinction of their physical constitution. This I believe is established.

Second hypothesis.—Every sensation of light is compounded of not more than three independent sensations, which do not influence one another. This is Young's theory. It follows that, if we denote the units of the three elementary sensations by i, j, and k, every sensation of light may be represented by an expression of the form,

$$Xi + Yj + Zk.$$

Third hypothesis.—The intensity of a sensation is proportional to the logarithm of the strength of the excitation, the barely perceptible excitation being taken of unit strength. Negative logarithms are to be taken as *zero.* This is Fechner's law. It is known to be approximately and only approximately true, for the sensation of light. From this it follows that, if x, y, z be the relative proportions of a mixture of three lights giving the elementary sensations i, j, k, the sensation produced by the mixture is

$$\mathrm{I} \log x . i + \mathrm{J} \log y . j + \mathrm{K} \log z . k,$$

where I, J, K, are three constants.

From these principles, it follows that if a light giving any sensation such as that just written have its intensity increased in any ratio r, the resulting sensation will be,

$$\mathrm{I}\log rx.i+\mathrm{J}\log ry.j+\mathrm{K}\log rz.k=$$
$$\mathrm{I}\log x.i+\mathrm{J}\log y.j+\mathrm{K}\log z.k+\log r\,(\mathrm{I}i+\mathrm{J}j+\mathrm{K}k).$$

Thus, the result of increasing the brilliancy of any light must be to add to the sensation a variable amount of a constant sensation, $\mathrm{I}i+\mathrm{J}j+\mathrm{K}k$. And all very bright light will tend toward the same color, which may therefore be called the *color of brightness.* Moreover, if the three primary colors be mixed in the proportions which each by itself is just perceptible, the sensation produced will be

$$\log r\,(\mathrm{I}i+\mathrm{J}j+\mathrm{K}k),$$

and can only differ by more or less.

Now I find, in fact, that all colors are yellower when brighter. If two contiguous rectangular spaces, illuminated with the same homogeneous light, uniformly over each, but unequally in the two, they will appear of different colors.

If both are *red* the brighter will appear *scarlet*;
" " *green* " " *yellowish*;
" " *blue* " " *greenish*;
" " *violet* " " *blue.*

If we have the means of varying the wave-length of the light which illuminates the fainter rectangle, we can improve the match between the two, by bringing the fainter toward the yellow. Such motions will converge toward a certain point of the spectrum which they will never cross,—a point a little more refrangible than D and having a wave length of $582\cdot10^{-6}$ mm., according to Ångström's map. If both rectangles be illuminated with this light, the fainter appears white or even violet, but if it be varied in wave-length with a view of improving the match, it will be found to return to the same point with the utmost precision.

It appears, therefore, that, if our hypotheses are correct, the color $\log r\,(\mathrm{I}i+\mathrm{J}j+\mathrm{K}k)$ is like that of the spectrum at $\lambda=582$, only that it contains less blue or violet and is consequently of greater chromatic intensity.

It further follows from Fechner's law that, if any light be gradually reduced in brightness, one element of the sensation will disappear after another; and that when very faint it will exhibit only one primary color, which is the one which it contains in greatest proportion relatively to the proportion in the light which has the color of brightness. Now, although this does not seem to be exactly the case, yet we do get some approximation to it. It is true that any light whatever, when sufficiently faint, appears white, owing to the self-luminosity of the retina. We cannot, therefore, unfortunately, get sight of the primary colors by reducing the light of three parts of the spectrum. But we may, as has often been suggested, make use of the principles of contrast. If any red spectral light be sufficiently reduced, it will perfectly match any less refrangible light. We may, therefore, say that a faint spectral red in contrast with a bright light of the same kind, excites with approximate purity one of the elementary sensations. The same thing is true of the violet; and therefore a rich violet may be taken as another primary color. In my book entitled Photometric Researches, the printing of which is nearly complete, I show reason to think that the pure green has a wave length intermediate between E and b. A faint green of this sort contrasted with a bright one appears as a very bluish green, and this may therefore be supposed to be the third primary color.

We have seen that it results from the theory that an increase in the brilliancy of any light adds to the sensation nothing of the peculiar color of that light, but only a certain amount of the color of brightness. If this be the fact, then the photometric sensibility of the eye should be the same for all colors. In order to ascertain whether this is so or not, I have made a series of determinations of my photometric probable error. Each determination was based on twenty-eight comparisons of two parts of the same colored disk. Since there were two unknown quantities, namely, the relative brightness of the two surfaces compared, and an instrumental constant, it follows that only twenty-six observations were effective for determining the probable error. Let R be my photometric probable error of a single comparison. Then the probable error of a single determination of R (which we may denote by r) would be $\frac{\cdot 51}{\sqrt{26}}\times \text{R}$, or say $\frac{1}{10}$R. Having made a considerable number of such determinations of R, with different colored disks, let us ascertain their probable error from their discrepancies, considering them as so many independent observations of the same unknown quantity, and denote this probable error by r'. If, then, R really is the same for all colors, we should have

$$r' = r,$$

or, at least, the difference should not exceed ρ, the probable error of r'; which may be calculated by the formula

$$\rho = \frac{\cdot 51}{\sqrt{m}}r',$$

where m is the number of sets of experiments diminished by 1. If, on the other hand, R varies with the different colors, and not merely accidentally, r' should have a larger value. The following are the values I obtained for R, the sum of the brightness of the two surfaces compared being taken as unity.

		R.	Diff. from mean.
Feb. 6.	White	·0041	+·0001
	Red, just before C	·0046	+·0006
	Chrome-yellow, A 2	·0032	−·0008
Feb. 7.	Red, just before C	·0040	±·0000
	Staat's emerald green	·0046	+·0006
	Carmine, B	·0044	+·0004
	Chrome-yellow, A 1	·0037	−·0003
	Purple, Hoffmann's violet RRR	·0033	−·0007
Feb. 13.	Red, just before C	·0048	+·0008
	Green, complementary to carmine	·0034	−·0006
	Blue violet, No. 2	·0048	+·0008
	Yellow, A 1, mixed with black	·0032	−·0008
	Mean	·0040	

After these experiments, the method of observing was changed, and I obtained the following:

Feb. 14.	White window-shade, ill. by sun	·0030	−·0002
	Brown	·0030	−·0002
	Greenish sky-blue	·0037	+·0005
	Very reddish purple	·0028	−·0004
	Yellow orange	·0032	±·0000
Feb. 15.	"Fundamental green of Müller"	·0030	−·0002
	Vermilion, half between C and D	·0034	+·0002
	Violet	·0032	±·0000
	Yellow	·0036	+·0002
	Mean	·0032	

We thus get from the

first twelve determinations, $r = \cdot 00040$, $r' = \cdot 00048$, $\frac{r'}{r} = 1\cdot 2$

last nine determinations, $r = \cdot 00032$, $r' = \cdot 00019$, $\frac{r'}{r} = 0\cdot 6$

and from the weighted mean, $\frac{r'}{r} = \cdot 96$, so that it appears from these experiments that the photometric susceptibility of the eye is the same for all colors. The result is, however, uncertain, because it may be that R is chiefly due to other sources of error than the limitation of sensibility; still, the experiments show as small a value of R as is usually obtained. I shall endeavor, by further observations, to obtain a conclusive result.

A further consequence of our hypotheses will be reached by differentiating the expression for a light-sensation. We have

$$d(\mathrm{I}\log x.i + \mathrm{J}\log y.j + \mathrm{K}\log z.k) = \frac{1}{x}dx.\mathrm{I}i + \frac{1}{y}dy.\mathrm{J}j + \frac{1}{z}dz.\mathrm{K}k.$$

Now, as x, y and z all exceed unity, the differential is greater the nearer unity x, y and z are. Hence, since the variation of the proportions of the primary colors with a variation of postion in the normal spectrum is uniform,* it follows that the change of color of the normal spectrum should be most rapid about $\lambda=582$, as it of course is. It is also obvious that if the total quantities of the three colors are nearly the same in different parts of the spectrum (I here refer to these colors not as really objective, but as measured in the usual objective way) then the part about $\lambda=582$ must be the brightest, another familiar fact.

I may observe that there is a modification of our formula for a sensation of light, which probably better represents the relations of the sensations. Writing, in the first place,

$$\mathfrak{i}=\mathrm{I}i \qquad \mathfrak{j}=\mathrm{J}j \qquad \mathfrak{k}=\mathrm{K}k$$

the formula is

$$\log x.\mathfrak{i}+\log y.\mathfrak{j}+\log z.\mathfrak{k}.$$

This loses its validity when any of the logarithms become negative. If z is the smallest of the three quantities, we may substitute

$$\mathrm{X}=\frac{x}{z} \qquad \mathrm{Y}=\frac{y}{z}$$

and the formula becomes

$$\log \mathrm{X}.\mathfrak{i}+\log \mathrm{Y}.\mathfrak{j}+\log z(\mathfrak{i}+\mathfrak{j}+\mathfrak{k}).$$

When x or y is smallest there will be two other formulæ. Now, as the variation in the brilliancy of the light affects only the last term of the last formula, and not the first two depending on X and Y, it is more than probable that the eye is habituated to separating the element of sensation which this last term represents, and which is continually changing its values, from the rest which remains constant. It is, therefore, likely that the classification of light into three kinds, according as the *violet*, the *red*, or the *green*, is contained in the smallest proportion, is one which has a relation to the natural powers of discrimination.

My observations have been made with an instrument for which I am indebted to the liberality of the trustees of the Bache Fund. I shall describe it on the occasion of publishing some work of a more serious character. The colored disks made use of were very kindly lent me by Professor Rood.

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* I will show this in a note in the next number of this Journal.

ART. XXVII.—*Note on the Binocular phenomena observed by Professor Nipher*; by JOSEPH LECONTE.

THE striking phenomenon described by Prof. Nipher, in the January number of this Journal, was described by Prof. W. B. Rogers, at the Newport meeting of the American Association, 1860, and may be found recorded in the 14th vol. of Proceedings, p. 197. It is only one of innumerable phenomena which are all explicable on the same general principles. The principles involved have been so fully set forth in several of my papers on binocular vision, especially in IV, "On a new method of representing visual phenomena," and VI, "On so-called images of illusion,"* that it is unnecessary to do more than briefly recall them here.

1. The field of view may be regarded as an outward projection of retinal states. As each eye has its own retina crowded with its own *retinal* images, so also each eye must have its own field of view and its own *external* images. There are therefore *two external images* for every object. These may be united, so as to see the object single; or may be separated, so as to produce the phenomenon of double images. *Moreover, the external images of different objects may also be* brought together and superposed at will. In all discussions of binocular phenomena, therefore, it is absolutely necessary that we speak not of objects but *of external images, the signs of objects.*

2. In binocular vision with the optic axes parallel, as in looking at a distant object, the whole visual field with all its external images or objects is shifted by the right eye a half interocular distance to the left, and by the left eye the same distance to the right; so that the two visual lines are brought together in the middle, and combine to form a common median visual line, and the *images of all objects in these lines are brought together and superposed.* This is the necessary result of the law of corresponding points. Retinal images of all objects in the visual lines fall on corresponding points, viz: the central spots; their external images are therefore thrown to the same place in space and are therefore superposed.

Now, in the experiment of Prof. Nipher, the visual line of the right eye passes through the axis of the tube and pierces the center of the circular visible area of the object regarded, while the visual line of the left eye pierces the left hand or paper-sheet or other object placed before it, at a point distant about 2½ inches (an interocular space) from the axis of the tube. Therefore the center of the circular area regarded by the right eye, and the spot on the hand or paper sheet pierced by the left visual line, by the law stated above, *are brought together and superposed.*

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* See this Journal, Jan. 1871, and Dec. 1871.

One thing more to complete the explanation. The impression on the right eye prevails over that of the left—the impression of the circular area *obliterates* that of the corresponding spot on the hand or paper sheet, for two reasons; first, because the circular area is strongly differentiated from the rest of the right eye field of view (the dark interior of the tube) while the corresponding spot on the left-eye field is not thus differentiated; and second, because both eyes are focally adjusted for the distance of the object seen by the right eye only. Thus it comes to pass, that the right eye sees *only the circular area*, the rest of its field being very dark: while the left eye sees *all its field* except the spot covered by the circular area. But if an ink spot be placed on the hand or paper sheet just where the visual line pierces, then the first cause mentioned above will be removed and the strongly differentiated ink spot will be seen in the center of the circular area.

Berkeley, Cal., Feb. 7, 1877.

ART. XXVIII.—*Revision of the genus Belemnocrinus, and description of two new species*; by CHARLES WACHSMUTH and FRANK SPRINGER.

IN 1862, Dr. C. A. White described a type of Crinoids from the Burlington limestone of Iowa under the generic name *Belemnocrinus*, of which he had discovered only a single species, *B. typus.* The description, with a figure, was published in the Proceedings of the Boston Society of Natural History, vol. ix, p. 13. Messrs. Meek and Worthen in the Report of the Geological Survey of Illinois, vol. iii, p. 463, described another species, *B. Whitei* from a specimen having only the calyx preserved. Count Pourtales, in the Illustrated Catalogue of the Museum of Comparative Zoology at Harvard College, No. 8, p. 29, has made some interesting observations upon the relations of *Belemnocrinus* to the recent genus *Rhizocrinus*, and further expressed the opinion that *Belemnocrinus* does not possess, as Dr. White supposed, five small basal plates below the long plates which compose the greater portion of the calyx, but that these long plates are themselves the true basals, thus exhibiting a very marked resemblance to *Rhizocrinus.*

A careful examination of some recently acquired specimens of this genus, including two new species in an excellent state of preservation, and a comparison of these with the original specimens heretofore described, afford us new light in regard to the structure of this interesting type of fossils, and it enables us to confirm the opinion of Count Pourtales, thereby rendering a revision of the generic formula and description appropriate and necessary.

A specimen of *B. Pourtalesi*, W. & S., has been deprived of the column, and the lower part of the cup is somewhat crushed, in such a manner that two of the long plates are separated along their entire length, exhibiting the sutures to the central perforation which leads into the column. The lower extremities of these plates are excavated, forming a concavity for the insertion of the pentagonal column, the marks of its attachment in a pentagonal outline are plainly visible, thus proving beyond the slightest doubt that these long plates rested directly upon the column, and formed with the first radials, the cup which encloses the visceral cavity. From these facts it follows that the long pieces, which were considered to be subradials, both by the author of the genus and by Messrs. Meek and Worthen in their description of *B. Whitei*, must now be designated as basal plates.

Additional light has been thrown upon the construction of other parts in this genus; every one of the four known species is furnished with a strong proboscis, inflated toward the top, and resting upon the single large anal plate which is a part of the wall of the cup. The exact structure of the summit of the calyx has not as yet been made out, but the comparatively massive character of the plates which compose the proboscis, as well as the size of that organ, render it altogether probable, that it was supported by a solid dome.

The arms, as observed in three of the four known species, are ten in number. They are provided with long, comparatively heavy pinnules, originating on the longer margins of large, wedge-form joints, which alternate with other joints of quadrangular outline, thus giving two rows of pinnules, alternately arranged, to each arm. In both of our new species these pinnules are simple; while those of *B. typus* are furnished with secondary pinnules, which are alternately arranged as the primary pinnules The arms of this genus bear in proportions and general aspect some resemblance to those of *Poteriocrinus*, but they are in fact widely different. In *Poteriocrinus*, the arms divide upon a bifurcating plate or joint, into equal branches, which rest upon the upper faces of this joint; while in *Belemnocrinus* the branches are true pinnules, and not armlets, they spring from the long latteral margin of the syzygial joint, not from its upper side. We have in our possession a specimen which in general aspect somewhat resembles *Belemnocrinus*, the elongated basal plates form here a cylinder apparently solid, almost precisely similar to that of *B. typus*, and as the upper portion of the calyx is somewhat distorted by pressure, it was at first supposed to be a *Belemnocrinus.* Upon removing the calyx from the surrounding matrix and arranging the plates in their natural position, it was found to possess a series of large sub-radials resting upon the basals, the anal plates arranged as in *Poteriocrinus*, thus exhibiting a fundamental difference from *Belemnocrinus.* Careful examination of the interior part of the cylinder formed by the basal plates, showed that they are thin and enclosed a comparatively large cavity, reaching nearly to the bottom of the cup, thus proving in a highly satisfactory manner the value of the peculiar characters of *Belemnocrinus.*

We are unable to agree with Dr. White in referring this genus to the *Cyathocrinidæ*, as it does not possess the general appearance of that group, nor does it agree in the generic formula as herein given. The slender ovoid or cylindrical base, the long solid basal plates, the shallow cavity in their upper part, and the comparatively small size of the visceral cavity are features which remove *Belemnocrinus* far from *Cyathocrinus*, or any of its allied genera. These characters show its affinities rather with the Jurassic genus *Apiocrinus*, to which in the construction of the calyx and inner cavity, it is more similar and seems to bear a closer relation, than to any other known group.

The resemblance to the recent genus *Rhizocrinus*, pointed out by Count Pourtales, is very close and interesting, even more so than he perceived, since we cannot agree with him that the first radials are movable in *Belemnocrinus.* On the contrary we find them to be closely joined with each other and with the anal plate by exact sutures, the anal plate being in line with them, forming the cup, and supporting upon its upper face the heavy proboscis. The succeeding radials have spaces between the rays, showing them to have been free. The most important difference, and indeed the only essential distinction between these genera in their external structure is found in the solid proboscis and covered dome of *Belemnocrinus.*

As a result of the foregoing observations we give now the following revised

GENERIC FORMULA.

Basal plates, five; long, narrow, forming an ovoid to cylindrical cup, which is nearly solid, having a small central perforation, and a shallow subconical excavation at its upper end, which forms a part of the visceral cavity.

Radial plates, four to five × 5; the first series with the anal plate joined at the sutures and composing a part of the cup; the succeeding radials free.

Anal plate, one; supporting a rather long, comparatively large proboscis. Dome covered by solid plates, arrangement unknown. Arms, ten so far as observed. Pinnules long and strong. Column pentagonal.

As yet found only in the Upper and Lower Burlington limestone.

The following species, new to science, have been discovered by us:

Belemnocrinus florifer, n. sp.

Smaller than *B. typus.* Column comparatively large, composed alternately of large and small joints, the smaller of which are nearly regular pentagons, and the larger pentagonal in outline, arched at the angles, notched in the middle of the sides making the column in general distinctly pentagonal, crenulated transversely, with a somewhat interrupted longitudinal furrow along the middle of each side. To the sixth and eighth large joint from the base, are attached radicular cirrhi which originate in the depressions or notches on each of the five sides of the joint. Traces of other sets of cirrhi are visible lower down on the column. They are all arranged precisely as those of *Pentacrinus Caput-Medusæ*, to the column of which this is in aspect strikingly similar. The cirrhi are long, slender, tapering to the tips, with joints longer than wide, and they increase in size as they approach the root.

The calyx is comparatively low, about two thirds as wide as high, ovoid below, turbinate and rapidly expanding above, constricted about the middle, with a deep transverse suture. The five basal plates are smooth, about three fourths as wide as high, slightly widest near the top, forming the ovoid portion of the calyx, gently expanding from the column outward and upward. They are constricted and abruptly truncated at the summit and appear as a heavy band around the lower part of a second cup which seems to rest in this one. The first radials are large, more than one half the size of the basals, a little higher than wide; outer surface strongly arched, curving rapidly inward at their junction with each other, thus forming deep vertical sutures. They compose, with the anal plate, a cup of conical shape whose sides are crenulated or scalloped by the arching of the plates and the depression of the sutures, and the diameter of which at the bottom is considerably less than that of the ovoid basal cup beneath, in which, rather than upon which, it seems to rest. The radials lie in a line with the sutures of the basals and rest apparently upon the inner edges of the upper faces of these plates. The upper portion of this conical cup in turn projects outward in a rim or band enclosing the arm bases, the arms seeming to proceed from the inside, the calyx and arms thus presenting the peculiar appearance of a bouquet of flowers in a conical vase, which in turn rests in an egg-shaped cup truncated at the base, thus suggesting the specific name. The upper faces of the first radials are truncated, and upon their inner edges rest the free radials which are four in number, about one-fourth the size of the first radials, a little wider than high and of uniform dimensions up to the arms. The plates of this series are rounded, strongly constricted, transversely in the middle, expanding at their upper faces, producing a rim which envelopes the lower part of each succeeding piece, this rim or wrinkle being rather thicker and more prominent at the lateral margins. The fourth free radial is pentagonal in form, the two upper faces forming an obtuse angle and supporting the arms which are simple throughout their entire length, thus giving two arms to each ray or ten to the species. Arms comparatively very long, rounded, tapering very gradually to the tips, composed of joints which are constricted in the middle, marked by strong lateral wrinkles, thickened at the upper margin to embrace the succeeding joints just as in the free radials. In the lower part of the arms, apparently every third joint, is a syzygium, wedge-form in shape, with quadrangular joints between; while in the upper part the joints are alternately wedge-form, and to the longer margins of these joints the pinnules are attached. These syzygial joints are strong, prominent, and give to the arms an obtusely zigzag appearance. Pinnules simple, rather heavy, very long, directed upward, lying closely along the arms, composed of rectangular joints twice as long as wide, and of nearly equal size throughout their length. Anal plate, rather large, quadrangular in outline, its upper face in a line with the top of the first radials. From the inner part of the upper truncate face of this plate proceeds a proboscis, in height equal to three-fourths the length of the arms. The lower part is composed of large plates nearly equal in size to the free radials, longitudinally arranged, each one resting upon the upper truncate face of the preceding one. Proboscis slightly inflated, the upper part composed of small nodose plates irregularly arranged, while its summit is surmounted by a set of prominent spines whose arrangement cannot be exactly determined.

The entire surface, with the exception of the basal plates, (even the pinnules) is covered by strong wrinkles which produce a peculiar carinated style of ornamentation.

This species is so well marked, and so unlike any other described form, that it may be distinguished with the greatest ease. It differs from *B. typus* and *B. Whitei* in its shorter basal pieces, the extreme size of its first radials, and in the peculiar attachment of the first radials to the basals. In both these species, the suture between the basals and first radials is not prominent, and the latter plates form a continuation of the cylindrical basal portion, while in our species the depth of the transverse suture, the beveling and constricting of the upper edges of the basals, gives to the basal portion the appearance of enclosing the cup which is formed by the radials. It differs from those species also in the highly arched surface of the first radials and the deep sutures between them, which give to the upper part of the cup its crenulated aspect. Also in the carinated surface. From *B. typus*, it further differs in the mode of attachment of the free radials and arm joints, the rim-like projection at the upper face of each plate, and in the strongly pentagonal and crenulated column.

It differs from our species *B. Pourtalesi*, in most of the above particulars and in the proportionally smaller size of its free radials, in the succession of the syzygial joints, and in the simplicity of the pinnules.

The specimen from which our description is made, is in a most perfect state of preservation, showing column, calyx, proboscis, and arms, the calyx being plump and every plate exactly in position.

Geological position and locality: from a thin cherty layer near the middle of the Upper Burlington limestone, Burlington, Iowa. Collection of Charles Wachsmuth.

Belemnocrinus Pourtalesi, n. sp.

Smaller than either of the other described species. The column is unknown, but, from the impression of its attachment to the lower excavated parts of the basal plates, it was evidently more or less pentagonal.

Calyx low, about two thirds as wide as high, basal-cup subglobose, constricted and truncated above and deeply excavated below for the reception of the column. The portion composed of the first radials and anal plate, being a little less in diameter at its junction with the basals, expands upward and gives to the whole calyx a form somewhat urn-shaped.

Basal plates nearly uniform in size, two-thirds as wide as high, slightly widest above, strongly convex and bulging in the middle, being curved somewhat like the staves of a cask, upper faces nearly truncate, lower faces truncated with abruptly rounded edges and excavated. They are heavy plates, solid below, leaving only a small perforation connecting with the column.

Radials, four. The first radials, alternately arranged with the basals, are only one-third of their size, wider than long, quadrangular, closely joined at the lateral sutures, and slightly set in from the outer upper edge of the basals, leaving a rather deep transverse suture. Second and third radials as wide as the first and more than twice as wide as high. Fourth radials larger than the others, pentagonal, supporting upon their upper *sloping faces* the free arms.

rms comparatively robust, tapering rather rapidly to the The arm joints are at their surface angularly elevated in middle, depressed toward the sides, the sutures between ı have at the middle angular part of each joint a strong nward curvature, a peculiarity which is also observable in adial series. The arms in this feature recall the charactic structure of those of *Taxocrinus* and *Forbesiocrinus.* ughout the greater portion of the arms, every alternate is a syzigium, very obtusely pentagonal, twice as large as ther arm joints, and to the longer margin of each which is tly angular, is attached a pinnule. The pinnules originate very distinct articulating scar near the upper part of the The intermediate plates are quadrangular in outline. n the bifuricating radial to the second pinnule two quadranr joints are interposed between those to which the pinnules ttached. The great size of the syzygial joints, as compared the others, and their rather pentagonal shape, cause the ules to branch from the arms at a considerable angle, and give to the arms a marked waving form. The pinnules g alternately from every second syzygial joint on either of the arms, they are simple, composed of quadrangular s, heavy, long, tapering but slightly, nearly all thus taining the same size throughout their entire length.

he ventral sides of the arms and pinnules are in our speciperfectly covered with alternating minute plates. The arrangement of plates has been observed by us arching ventral furrow in the arms of *Cyathocrinus*, *Poteriocrinus*, *athocrinus*, and *Cupressocrinus*, and Messrs. Meek and Worhave observed it in the arms of *Batocrinus.* We are led elieve that the ventral furrow was similarly arched in all ozoic Crinoids.

he anal side and proboscis are hidden in our specimen and ot be described. The surface of the radials and arms is stinctly carinated.

Pourtalesi can be readily distinguished from any other wn species. From *B. florifer*, which it perhaps most nearly mbles, it differs in its more globose basal cup, its smaller radials and its wider free radials, which are fully twice as in that species, also in the proportionally shorter and ier brachial pieces, the extreme size of the syzygial joints ompared with the intermediate ones, the robust and rapidly ring arms, in the angular form of the arm joints, the curving res between them, and in the peculiar shape and crenulated er part of the calyx of that species. From *B. Whitei* it rs in its shorter, more globose and smaller cup and in the of the first radials. From *B. typus* in the same respects, also in the waving form and angular surface of the arms.

We take pleasure in dedicating this elegant species to Count L. F. de Pourtales, the eminent Zoologist of the Museum of Comparative Zoology at Cambridge, Massachusetts, who first called attention to the relations of this genus to one of the types of recent Crinoids.

Geological position and locality: from the lower part of the Lower Burlington Limestone, Burlington, Iowa. Collection of Frank Springer.

ART. XXIX.—*On Thorpe's and Bunsen's methods for the Estimation of Nitrogen in Nitrates;* by S. W. JOHNSON.—*Contributions from the Sheffield Laboratory of Yale College.* No. XLVI.

IN volume xxvi, pp. 541, 549, of the Journal of the Chemical Society, as well as in his treatise on Quantitative Analysis, p. 95, Thorpe has described a method of estimating nitric acid, in which this acid is reduced to ammonia by the use of slips of zinc coated with precipitated copper, a reducing combination first employed by Gladstone and Tribe. The experimental results given by Thorpe in support of his method are such as apparently establish its great exactness, while in simplicity and ease of execution, it would seem to be quite superior to the similar methods that have been previously proposed.

Having occasion to make some determinations of nitric acid, I tested Thorpe's method in five distinct trials with pure sodium and potassium nitrates. The directions given by Thorpe in his Quantitative Chemical Analysis are as follows:

About 25–30 grams of thin sheet zinc are placed in a flask of about 200 c. c. capacity, and covered with a moderately concentrated and slightly warmed solution of copper sulphate. In about ten minutes a thick spongy coating of copper will be deposited on the zinc; the liquid is poured off the metals, which are now well washed with cold water and covered with about 40–50 c. c. of pure water. Weigh out about 0·5 gram of pure nitre into the flask connected with a condensing arrangement. The liquid is gradually heated and distilled for about an hour. The distillate is treated with platinum tetrachloride.

These directions were followed as closely as possible save that the distillate was received in a standard acid in order to measure the ammonia volumetrically.

In the first experiment 0·5712 of sodium nitrate were employed, containing 0·09408 of nitrogen. After distillation was concluded, the distillate contained 0·02947 of nitrogen. Thinking that the zinc hydroxide resulting from reduction of the nitrate might retain ammonia beyond the power of simple distillation to remove, although Thorpe makes no such suggestion, I added a quantity of newly fused, pure caustic potash, and more water and distilled again.

This second distillation gave additional ammonia equal to 0·0227 of nitrogen.

The total nitrogen thus obtained was:
1st distillation, 0·02947
2d " 0·02275
0·05222 instead of 0·09408
Or a deficiency of 45 per cent.

In a second trial, 0·6689 grams of sodium nitrate were taken. The conditions of reduction were as near as practicable the same as before, but on completing the first distillation the odor of nitric oxide was plainly evident in the receiving vessel, and the amount of free acid in the latter was greater than at the outset, the standard acid, not only being not neutralized by ammonia coming from reduction, but made more acid by the reaction of nitric oxide upon the oxygen and water of the condensing vessels.

In a third experiment with 0·4193 grams of pure potassium nitrate, 40 grams of cleansed zinc were covered with concentrated copper sulphate solution for fifteen minutes, the precipitated copper was washed with great care to avoid as much as possible detaching it from the zinc. 40 c. c. of water and the nitrate were added, the mixture heated very gradually and distilled finally with addition of more water, for one hour. The result was like that of experiment 2.

A fourth trial resulted in the same increase of acid in the receiver. In all these cases the copper was very loosely attached to the zinc, so that by mere washing much of it, and on boiling most of it separated.

I now referred to Gladstone's description of his method of preparing the zinc-copper couple, and made a fifth experiment, following his different directions as follows:

A weak solution of copper sulphate (1·5 per cent $CuSO_4$) was employed, and the zinc was let remain in it for some time until the color of the solution was very nearly discharged. The distillation was then conducted as Thorpe directs.

0·5338 grm. KNO_3 containing 13·84 per cent N.
yielded 5·20 " N.
deficiency = 8·64 " N.

Thorpe mentions no difficulty in the application of his process except in case of ammonium nitrate. With reference to its analysis he says, "the discordances appear to depend upon differences in the strength of the solution and the amounts of zinc and copper taken. If the solution is too strong, nitrogen dioxide is evolved, and if the amount of zinc and copper be insufficient, the reduction is incomplete." It is evident that the process needs further study to define the conditions of its successful employment.

In contrast with the above results I instance three estimations of nitrogen made by Bunsen's method,* on the same sample of potassium nitrate and with aid of the same standard alkalimetrical solutions as were employed in the experiments just described. In Bunsen's method the reduction is effected in the cold, in presence of 250 or 300 c. c. of water and excess of caustic potash by zinc-iron couples, prepared by twisting together sheets of the two metals.

The time of reduction in the first trial was twelve, in the others thirty, hours. After these times, the ammonia was distilled into the standard acid. The results were as follows:

	1.	2.	3.	Theory.
Nitrate taken,	0·4593	0·3374	0·2651	
Nitrogen found,	13·29 p. c.	13·49 p. c.	13·25 p. c.	13·84

The results fall short, it is seen, from 0·35 to 0·60 per cent.

My acknowledgments are due to Mr. E. H. Jenkins, for assistance in these trials.

ART. XXX.—*Westfield during the Champlain Period;* by J. S. DILLER, of Westfield, Massachusetts.

WESTFIELD, Massachusetts, is nine miles west of Springfield, and six miles north of the Connecticut State line, in a valley cut off from the western part of the Connecticut valley by the Divide Range (the trap ridge extending south from Mount Tom). The village of Westfield is situated between Westfield River and Westfield Little River. These rivers flow eastward, across the valley, and, after uniting a mile east of the village, their waters pass through the Divide Range into the Connecticut River below Springfield.

The region contains three extensive plains. Hampton Plain, beginning near Hampden Ponds, four miles northeast of the village, extends south to the Westfield River. Avenue Plain extends, from the mountains west of Westfield, east between the two rivers to the village. Poverty Plain begins south of the rivers, and extends south by the Southwick Ponds into the Farmington valley. Stratified deposits in the northern part of the Hampton Plain, near Hampden Ponds, are 286 feet above mean sea-level. From this place the plain slopes south relve feet per mile to near the Catholic cemetery, and is there 9 feet above mean sea-level, or 104 feet above highest modern od-level at Westfield. A plain extending south from near sthampton toward the Hampden Ponds, slopes in the same

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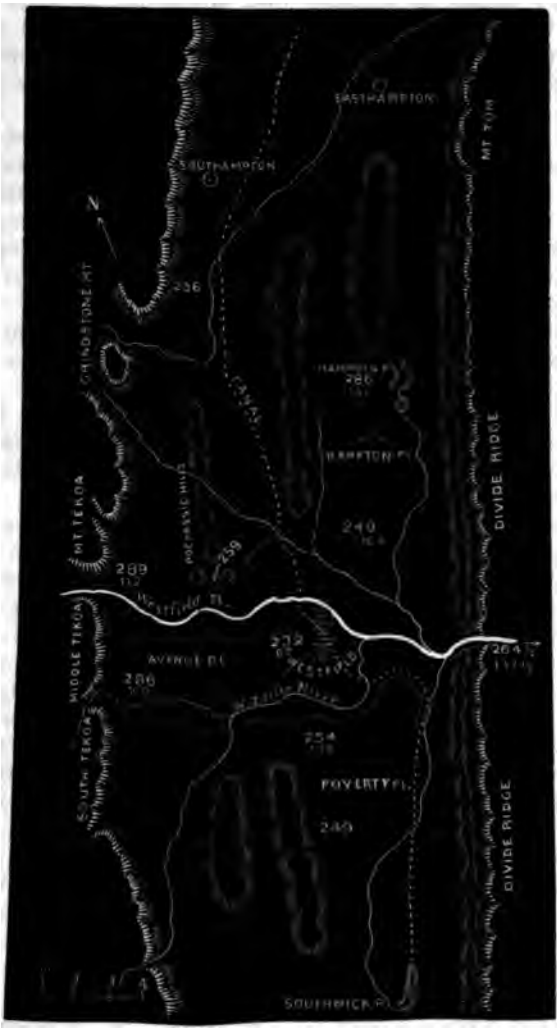
* Fresenius's Zeitschrift, x, p. 414.



ection. The divide between Northampton and Westfield rossed, west of Hampden Ponds, by a valley through which old canal extends. The highest plain in this valley near uthampton is 256 feet above mean sea-level, and slopes toward the south. The northern part of the Hampton Plain is made of very coarse material, which gradually becomes finer toward the south. In the gravel of this plain, pebbles of trap are found.

Poverty Plain is highest just south of Westfield Little River, where the stratified deposits are 254 feet above sea-level (109 above flood-level at Westfield), and slopes toward the south three and a third feet per mile. The material of the Poverty Plain is finer than that of the Hampton Plain. Poverty Plain is separated from Hampton Plain by the valley of the two rivers, and extends south into Farmington valley. The slope of these plains toward the south, and the grade in the material of the Hampton Plain in the same direction, are unmistakable evidences that during the period of their deposition, the Champlain period, the water must have flowed over these plains from north to south.*

The appearance of trap pebbles in the Hampton Plain points to the same conclusion. Not any trap rock is found in the basin of the Westfield River west of the Divide Range. Hampton Plain is separated all along its eastern boundary from the Divide Range (trap) by a ridge of sandstone rising far above the stratified drift of the plain. From these conditions it is evident that the trap could not have been washed into the plain from either the east or west. Following the Divide Range to Mt. Tom, it will be seen that this mountain owes its height to the westward advance of the trap and underlying shale, making it to rest directly upon the hard conglomerate which forms a separate ridge south of Mt. Tom. The talus of trap on the western side of Mt. Tom would be carried, by a stream flowing south, along the western base of the mountain, directly into the Hampton Plain. There seems to be no doubt that the pebbles of trap are from Mt. Tom, and were carried into their present position by a stream from the Connecticut River flowing south (as Professor Dana has already shown), west of Mt. Tom, over the Hampton and Poverty Plains into the Farmington valley.

The highest stratified deposits in the vicinity of Westfield are near Mt. Tekoa, 289 feet above the sea, and 112 feet above the flood-level of the Westfield River where it issues from the mountains. Hampton Plain, as already stated, rises 286 feet above the sea. According to Professor Dana, there is a terrace at Tariffville, Conn., fourteen miles south of Westfield, in the same valley, having a height 275 feet above sea-level. He has taken this as proof that the height of the flood over the middle part of the Westfield basin was at least 275 feet. The heights

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* Professor J. D. Dana derived the same conclusion, this Journal, vol. x, Dec. No., 1875, pages 504–507.

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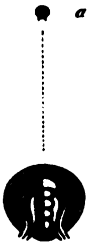

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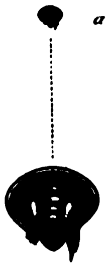

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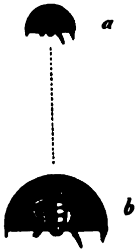

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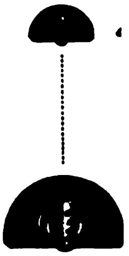

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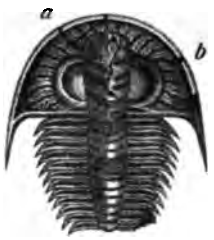

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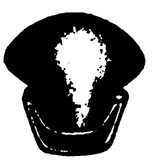

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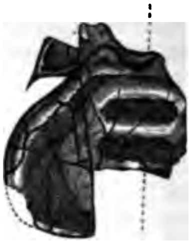

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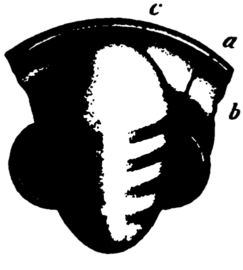

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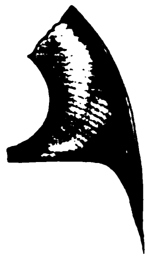

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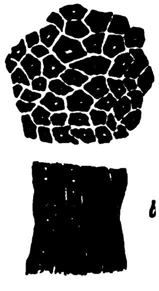

S. W. Ford del.

[illegible]

given above, one in the valley and the other, a greater height, upon its side, show, after making reasonable allowance for the slope of the water, that the level of the highest flood was at least 280 feet above mean sea-level.

During the greatest flood, the Westfield River and the Westfield Little River, joining the waters from the Connecticut, flowed south over the Poverty Plain into the Farmington valley. The lower deposits in this vicinity were made by the Westfield Rivers before the overflow from the Connecticut began. One of the first results of the overflow from the north must have been to fill the former valley of the Westfield Rivers, so that during the time of greatest flood the Hampton and Poverty Plains must have been one continuous plain.

The north end of the Poverty Plain is five feet higher than the south end of the Hampton Plain, and while the latter slopes twelve feet per mile the former slopes only three and a third feet per mile. The material of the Poverty Plain is finer than that of the Hampton Plain. The differences in height, slope, and material, are all due to the confluence of the three streams upon the Poverty Plain, and to the damming of the water by the Southwick Divide.

The Avenue Plain, at its western extremity, reaches its greatest height, 286 feet above mean sea-level and 109 feet above flood-level of the Westfield River, at Mt. Tekoa. From this place it slopes east sixteen feet per mile to the village cemetery, where its height is 232 feet and 87 feet above flood-level of the Westfield River at Westfield. The east end of the Avenue Plain is at least seventeen feet lower than the adjacent ends of the Hampton and Poverty Plains, showing that seventeen feet of stratified deposits must have been swept off the east end of Avenue Plain.

When the flood subsided, the overflow from the north ceased, and the Westfield rivers began to flow once more through the Divide Range into the Connecticut. By their conjoined action they eroded the Avenue Plain to its present level, and cut for themselves, across the once continuous plain, deep valleys, with the terraced sides that now appear.

Art. XXX.—*On some Embryonic Forms of Trilobites from the Primordial Rocks at Troy, N. Y.*; by S. W. Ford. With Plate IV.

The existence, in the case of a number of species of Bohemian Trilobites, of a series of forms showing that, before reaching maturity, the animal passed through several widely distinct phases of growth, is a fact long ago made familiar to geologists by the researches of M. Barrande. In one instance, that of *Sao hirsuta*, he has shown that twenty such phases are passed through, the earliest and simplest forms being of almost microscopic minuteness and presenting scarcely any resemblance to the individual when completely developed. These phenomena have been styled by Barrande the "Metamorphoses of Trilobites;" and in his truly magnificent work on the Trilobites of Bohemia (Systême Silurien de la Bohême, vol. i, 1852,) they are fully and ably set forth and discussed. Hitherto, however, no example of a truly embryonic form of trilobite, or one showing that the animal was mainly developed after quitting the egg, has been found in other than Bohemian strata; a fact which, when we consider the prodigious numbers of these animals that existed in Paleozoic times, the care with which the rocks in which they occur have been explored in many countries, and the profound study which their remains have received at the hands of many distinguished investigators, would seem to indicate that, in the greater number of species, no such forms ever existed. I beg leave to submit herewith the evidence I have obtained of the metamorphoses of an American trilobite, the species being the *Olenellus* (*Elliptocephalus*) *asaphoides* of Emmons. I shall discuss this evidence, together with certain other material which I possess pertaining to this species, under the following heads:

Genus OLENELLUS Hall.

OLENELLUS (ELLIPTOCEPHALUS) ASAPHOIDES Emm.

I. *Embryonic Forms.*

In the spring of 1868 I discovered several specimens of this species in the limestone beds at Troy, showing clearly the characters of *Olenellus*, which were afterward fully identified with the Washington County form by Mr. Billings. Since that time I have added to my list of specimens whenever opportunity has offered. Although some of the specimens obtained early in the course of my investigations appeared to me somewhat rudimentary in character, yet it is only of late, and after laboriously working away the partially enveloping rock, that I have become fully aware of the real richness of the material. Further researches will doubtless supply much that is still desirable.

Fig. 1*a* represents, natural size, the earliest stage of growth observed, and 1*b* the same enlarged five diameters. The specimen is nearly circular, one line in greatest width and length, with a wide concave border which, toward the edge, is bent upward so as to form a neat marginal rim. The glabella is three-fifths the total length. It is divided into five distinct lobes by four well defined furrows extending all across. The

rd lobe is considerably larger and spreads out laterally
nd the others, which are of nearly equal shape and dimen-
. It stands out prominently in the specimen. The eye-
are of an elongate semi-lunate form, and, springing from
ostero-lateral angles of the forward lobes of the glabella,
d backward nearly as far as the last glabellar furrow. At
osterior extremity of each and in direct continuity with
is a well-defined rounded ridge which extends outward
ackward toward the postero-lateral margin, with the raised
of which it unites to form a slender spine. The spaces
een the eye-lobes and glabella are tumid and are prolonged
ward as two spines lying within the former. These I shall,
nvenience, call the "inter-ocular" spines. I have no doubt
hat all of these spines terminate in acute points, as they
ll seen to taper slightly in the specimen; but as they pass
th the stone a short distance from the disk, I have
ght it better not to run the risk of destroying them
ether in attempting to further develop them. Between
wo spines last described lie the last glabellar lobe and its
ndage, the latter a simple, smooth, narrow, nearly flat or
feebly convex plate, convex in outline behind, and giving
e specimen its nearly circular form. This plate I consider
a rudimentary pygidium. I believe this to be one of the
rudimentary trilobitic forms ever discovered. At present
pears to me to be equally humble in structure with the
representing the first stage of growth of *Sao hirsuta* illus-
d by Barrande. The head is greatly predominant. There
thorax, and no pygidium properly so called.

ith regard to the nature of the spines and ridges which I
just described I became greatly puzzled as my study of
pecimen continued. At first I was disposed to look upon
as simply ornamental in their nature, regarding the ridge
h runs backward from the eye-lobe as simply the eye-lobe
fancifully prolonged. Afterward, however, I was led to
the *economy* of the animal organization into account, and
the moment of doing this I was conducted to very differ-
onclusions from those first entertained. I believe the
spine of this individual to represent the permanent spine
e genal angle in the adult, and the little ridge which
backward from the eye-lobe to this spine and helps to
it to represent that portion of the posterior margin of
s which lies between the genal angle and the facial suture.
inter-ocular spines I am inclined to regard at present
ving been most probably protective in their office. Be-
the ridges extending from the eye-lobes and these spines
is an open space or *slit* in the shield. This space repre-
, I believe, the position of the posterior portion of the

facial suture in the adult. At this stage that portion of the posterior margin of adults which lies within the sutures is not even indicated. The specimen presenting these remarkable features of structure is in a beautiful state of preservation.

Fig. 2*a* represents another specimen, natural size, and 2*b* the same enlarged three and one half diameters. The lower left hand portion of the border is slightly restored in each. This specimen is, in extreme width, two-thirds larger than the first example, and in extreme length, exclusive of the spines, one-half larger. The form has changed considerably, but it requires but a moment's attention to convince one that the fundamental structure is, in all respects, the same with that of the preceding example. The shield is more spread out laterally, and markedly so at the mid-length; the eye-lobes in their forward portions are more arched; the glabella is more acutely and regularly tapering; and the proportional distance between the inter-ocular spines at their origin is considerably increased. The glabella is marked by four distinct furrows extending all across as before. Immediately in advance of the fourth or foremost furrow there is a slight ridge extending all across the anterior lobe, which gives to the eye-lobes the appearance of meeting on the median line of the glabella. The neck-furrow is strongly marked. On either side of the neck-segment is a short, deep, longitudinal furrow with an elevated rim bounding it behind. We have here rudely sketched out that portion of the posterior margin of adults which lies inside of the sutures. In contact with this margin there is a somewhat convex, triangular body, the central portion of which is damaged, but which shows on each side two or three obscure furrows extending outward and backward. This body, both from what Barrande has taught respecting the mode of development of the thorax of trilobites and from the appearances themselves, I consider to be most probably a rudimentary thorax and pygidium combined. From the even manner in which it is outlined it is probable that none of the segments were yet free. The surface of both this and the foregoing specimen is smooth.

Now, if we examine the figures it will appear evident, I think, that, between 1 and 2, one or more intermediate forms may exist, and between 2 and 3 a considerable number of such forms. As yet, however, no such forms have been obtained. Figure 3*a* shows, natural size, and 3*b* twice enlarged, a head whose development is evidently nearly completed, but which is, nevertheless, embryonic in certain of its features. There still exist the strong inter-ocular spines and the glabellar ridge uniting the eye-lobes in front. The glabellar furrows also extend all across, but become fainter on the median line. The eye-lobes are rather more regularly curved than represented in the figure.

s specimen we have the first indication of the fine system
face lines which ornaments so beautifully, in many instan-
e adults. From the posterior extremity of the eye-lobe
is a slender though distinct ridge running backward par-
with the inter-ocular spine, lying close alongside, to the
nal edge and forming with it a continuous elevation.
en this little ridge and its adjacent spine is the place of
ture. In this, as in the preceding example, the inner
d portions of the posterior margin wall against the inter-
spines. These spines are here clearly seen to lie *in* the
nal border, or rather between its still disunited outer and
portions, appearing as if occupying a little notch in that
r especially intended for their reception. The spines of
sterior angles are only partially preserved.

figure 4*a*, which is of the natural size, and *b* the same
ed as before, the posterior margin is continuous or united
sutures; but there is a little ridge running from the base
eye-lobe to the marginal edge, as in the preceding case.
haracter is likewise shown in all perfect adult specimens.
pecimen is perfect excepting the posterior spines. The
ters are all only those of adult growth. There are three
of glabellar furrows in advance of the neck-furrow, none
ich reach the median line, and in addition, as is likewise
f most adult specimens, a short, fainter fourth pair in front
anterior extremities of the eye-lobes. The neck-furrow
tinuous all across. The spaces between the eye-lobes and
lla are but moderately convex and were no longer pro-
with spinous appendages. The surface of the cheeks is
ented with exceedingly fine waved lines, best shown in
ncavity just within the marginal rim.

ave purposely dealt with figure 4, under this head, in
to prepare the way for a better understanding of certain
es of structure presented by the embryonic forms to
I wish more particularly to refer. Returning to figure
on comparing this form with 2*a*, we observe the princi-
fferences to consist in the relatively greater lateral expan-
f the postero-lateral portions of the shield in the former,
being extended so as to give to the form a nearly semi-
ar outline; the relatively smaller size of the tumid spaces
en the eye-lobes and glabella; the relatively nearer ap-
h of the posterior portions of the eye-lobes to the glabella;
the presence of a nearly perfectly formed, though not, as
nited posterior border. With the completion of the perfect
of the posterior margin at the sutures, the inter-ocular
appear to have been no longer of use and were altogether
essed. Figure 4 is an example of this. But in all essen-
atures of structure I believe 2 and 3 to be fundamentally

the same. If, in the case of figure 2 we were to suppose that portion of the ridge running from the lower extremity of the eye-lobe which does not enter into the composition of the spine of the general angle to be elastic, and then draw the lower end of the eye-lobe downward and inward as close to the glabella as possible, at the same time carrying the genal angle outward a little way, we should get a short horizontal posterior margin between the outer and inner spines. This is similar to what, I believe, has, in effect, actually occurred in the growth and development of this form, the growth being both inward or toward the line of suture and outward or toward the angle, giving us a form such as we observe in figure 3. I have no doubt but that future discoveries will bring to light forms illustrating this, and also showing us more fully the various stages of unfolding passed through in the development of this extraordinary species of trilobite.

II. *Adult Forms.*

Fig. 5 represents, twice enlarged, an unusually perfect specimen. It is of a young individual, but the characters show that it was, without doubt, a fully developed form. The head is somewhat crushed and fractured, but the main features are beautifully shown. The thorax is incomplete, and the pygidium is wanting. There are twelve pairs of ribs preserved. These decrease in length in a regular manner, constituting an exceptional feature in the structure of the genus.* In one of the three specimens of this species figured in Dr. Emmons' works there are fourteen articulations in the thorax, but it is impossible to say whether this is the total number possessed by the individual. His figure also shows one of the posterior spines of the head in place with its characteristic surface-markings.† In our specimen the whole surface of the head beyond the eye-lobes and glabella is covered with irregularly alternating finer and coarser lines radiating outward to the margin. These lines are somewhat too coarsely represented in the figure, but it shows well the peculiar character of the ornamentation. In this specimen the slender ridges running from the eye-lobes to the posterior margin along the sutural lines are very apparent. The eye-lobes are not actually in contact with the glabella behind as shown in the figure, which would also slightly change the direction of the ridges extending from them. At *a* and *b* the shield is fractured, but I do not consider either fracture as coincident with the course of the suture. In fig. 8, which represents the glabella, eye-lobes, and portions of the cheeks of a large individual, the whole considerably weathered, there are three such fractures. Of these *a* coincides very nearly in relative position and direction with *a* in fig. 5. But this coincidence appears to me to be only accidental. It is possible, judging from a specimen in my collection showing the under side of the head with the hypostoma in place, that the line *c* coincides with the suture, but I do not feel at all satisfied of this. I have never been able to ascertain to my entire satisfaction the direction of the suture in front of the eye in any specimen. The shield appears to have fractured as easily in one direction as another. This would seem to indicate that the cheeks were very firmly united at the sutures in front. This, if true, has an important bearing upon what I have stated in regard to the mode of formation of the posterior border in the embryonic stages; for if, according to my view, the posterior portions of the sutures were, almost from first to last in the progress of the metamorphoses, only *indicated* by the structure, the spaces in the developing margin which they were to occupy being long left open, we can readily understand why the anterior portions of the shield should have been firmly held together. The changes that took place in the forward portion of the shield during the period of development were, as compared with those in the backward, relatively unimportant both as to kind and amount.

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* See Barrande,—"Documents anciens et nouveaux sur la faune primordiale et le Systême Taconique en Amerique." Bul. Geol. Soc. France, 2 Ser., vol. xviii, p. 203, 1861. Also, the writer, "Note on *Microdiscus speciosus*," this Journ., Feb., 1877, p. 141.

† "American Geology," pl. 1, fig. 18, 1855. See also "Taconic System," pamph., 4to, p. 21, 1844.

This species sometimes attained an enormous size. One specimen of the glabella in my collection is an inch in width at its narrowest part. The surface of the head in some cases presents an exceedingly ornate appearance. Occasionally the whole surface of the cheeks is covered with small polygonal areas having a little prominence in the center of each, these areas being formed by the irregular interlacing of the fine raised surface lines. In other cases this arrangement holds good for the more central portions of the cheeks, while toward the margin the lines become more regular in direction and better defined, and sometimes become so widely separated as to enclose two or more rows of what were before the little tubercles or prominences in the polygonal spaces. Figs. 10*a*–*b* are intended to illustrate what is here meant, *b* being a small segment of the outer portion of a cheek greatly enlarged, and *a* an enlargement of one of the inner portions. At other times the whole surface of the cheeks is covered with tubercles with no enclosing lines, and at still others with only irregular lines with no tubercles.

Fig. 9 is of a portion of one of the cheeks preserving its spine. The upper crust is nearly all removed, but at the spine we see it present with its usual ornamentation. The specimen is, for the most part, a cast in stone of the outer or lower surface of the "doublure," which is shown to be ornamented in much the same way as the upper surface of the shield. Along the outer edge there is a portion of the doublure itself remaining.

III. *The Hypostoma and Epistoma.*

Of the hypostoma of this species I have several specimens, one of which, a very perfect example, is here figured twice the natural size (fig. 6). Its form and structure both show it to be very closely related to the hypostoma of *Paradoxides.* The surface is smooth. The central body is exceedingly convex. In his description of the type of the genus, *O. Thompsoni* (13th Regents' Rep. and elsewhere), Professor Hall says of the hypostoma that it is "broadly ovate, little longer than wide." As this description was too imperfect to be made available in comparison, and was unaccompanied by a figure, we were thus left in doubt regarding the testimony of this, one of the most important parts of trilobites that can be employed in the identification or differentiation of genera. In the form of the hypostoma, the shape of the glabella, and in its *facies*, this genus is evidently closely related to *Paradoxides*, more closely I believe than to *Olenus*, as was originally believed by most paleontologists who investigated it. The glabella in all the species is widest at the frontal lobe. In the case of *O. asaphoides* we see that this is a feature that is early marked out in the structure.

In a small number of species of trilobites described and figured by Barrande, there is shown to exist a second plate quite similar in shape to the hypostoma, but placed in the interior of the cephalic shield. This he has called the "epistoma." We have not hitherto found this organ in any American trilobite. About three years ago I obtained an enormous glabella of *O. asaphoides*, beneath which there appeared to be at one point indications of the existence of a plate of different character from anything I had previously seen. The specimen remained in my hands in this state for a long time, but I finally succeeded in developing the body referred to, which is the remarkable form represented (nat. size) in fig. 7 of the plate. It shows a central or sub-central elevated area with two deep oblong parallel furrows; an elevated left-hand border, and between these a wide concavity. At the upper left-hand portion is the cast of a stout spine. Just to the right of this a portion of the plate has been removed. The surface presents a smooth polished appearance. This plate I believe to be the epistoma of this species.

The specimen whence this plate was obtained consisted as originally discovered of two parts, one showing the inner surface of the crust of the glabella, and the other its impression in

me. Beneath this latter, at about a line's depth, was
a portion of the plate in question. At present the
en consists of three parts, or rather four: (1) The inner
of the glabella; (2) a limestone cast of the same; (3)
istoma attached to the lower side of No. 2; (4) a cast
lower or mouthward side of the epistoma, and preserv-
spine. The layer holding the epistoma came away in
pieces. These have been glued together, and the rela-
the parts of all four of the pieces can be made out with
d certainty.

will be seen from the figure, the plate is in a fragmentary
ion. Compared with the hypostoma it is probably
nted in an inverted position in the drawing. The
portion in the figure is probably the backward portion
specimen. This is, moreover, its position beneath the
a. It lies diagonally across the latter, with its spinous
resting directly beneath the neck-segment. It has
ess become detached and slipped backward. It appears
robable that the straight dotted line in the figure indicates
imately the middle line of the perfect specimen. This
hat I desire to say upon the subject at present.

sum up: I believe the facts which have been presented
conclusively that we have in *Olenellus asaphoides* an ex-
of the metamorphoses of trilobites, and clear up some
that have always been in doubt concerning the genus,
s affording us a more complete life-history than we have
o possessed of any trilobite from American strata. In my
gation of this singular life-history I have striven earnestly
the record aright. How far I have succeeded in this must
for my fellow laborers in the department to determine.
of the specimens described and figured in this paper
ollected by the writer from the limestone beds of the
Potsdam Group at Troy, N. Y.

ork, February, 1877.

XXXI.—*The Winds of the Globe; or the Laws of Atmos-*
ic Circulation over the surface of the Earth; by JAMES H.
FIN, LL.D., Professor of Mathematics and Astronomy in
yette College.*

s volume, to which the author devoted many years of
labor, may be considered, as its title implies, an exten-

Winds of the Globe; or the Laws of Atmospheric Circulation over the surface
rth; by JAMES H. COFFIN, LL.D., Professor of Mathematics and Astron-
Lafayette College. xxvi and 756 pp. 4to, with 26 plates. Washington,
ompleted, on the author's decease, by Professor Selden J. Coffin, Ph.D.;
iscussion and Analysis by Dr. Alexander Woeikof.—Smithsonian Con-
s to *Knowledge*.

sion of his earlier treatise on the Winds of the Northern Hemisphere. Its design is to show

1st. The mean direction of the wind in all parts of the earth.

2d. The ratio that the progressive motion bears to the total distance traveled.

3d. The modifications that the mean current undergoes in the different seasons of the year.

4th. The directions in which the forces act that produce these modifications.

5th. The amount of their intensities.

6th. To show, by separate solutions for the surface winds and those indicated by the motion of the clouds, how the two differ, and how they differ according as we do, or do not, take into account the difference in the velocity of the different winds.

The data used for elucidating these points consist of series of observations on winds made at 3,223 different stations on land, and during numerous voyages at sea, extending from the parallel of 83° 16′ north latitude, to beyond the parallel of 75° south latitude, the extreme points ever reached by man, altogether embracing an aggregate period of over 18,500 years. If the area between latitude 60° N. and 60° S., where observations are more abundant, be divided into geographical squares, by drawing meridians and parallels of latitude 5° apart, of the 1728 squares so formed 1410 are represented in this work. The 318 vacant squares, from which no observations have been obtained, are as follows: Twenty-one in North America, mostly in British America; forty in the interior of South America; none in Europe; seventy in Central Asia; sixty-three in Africa; fifteen in the interior of Australia; one hundred and eight in the North Pacific Ocean; and one in the South Pacific Ocean.

It seems eminently desirable that the great paucity in the North Pacific Ocean, should be filled; particularly as it is supposed that the material for doing so exists, though entirely unreduced, among the archives of the United States Naval Department.

To facilitate condensation in the results, the stations that reported directly to the Smithsonian Institution have been grouped into convenient districts, about 100 miles square, and the total number of observations has been given for at least eight points of the compass, during each of the four seasons. In the case of most other stations, and particularly when the series extended through a long period of years, the total number of observations is given for each month of the year, and to sixteen points of the compass. By this summary the distinctive features of the system of winds in any part of the earth are not obliterated by condensation, excepting, of course, when those of a particular epoch are sought, as in the case of the investigation of storms. For this the present work is not available; although the author appreciated this end, as shown in his preparation of a previous work,* in which 300 pages are devoted to selected records from 400 localities in the United States, extending through several days each, in the case of storms that occurred in March and September, 1859, and noting not only the winds, but all the accompanying meteorological phenomena.

The method of summing and presenting this mass of material, is by five series: in each of which the separate seasons and points of the compass are kept distinct, viz:

I. The number of observations.

II. The number of miles traveled, as estimated by the observers.

III. The mean velocity in miles per hour.

IV. The number of observations taken on the upper current, as indicated by the motion of the clouds.

V. A velocity table computed from the first three series, the results of which will be noted farther on.

In series I, II and IV, the trigonometrical resultants are computed, both as to direction and the ratio of the resultant to the sum of the winds. Of these the work embraces 16,000 solutions, about one-half of which find place on the charts. The deflecting forces have been wrought out in about 8,000 of these instances.

The peculiarity of series V may be seen in an example. Certain stations in New Hampshire, north of latitude 40°, during the years 1854 to 1857 inclusive, give the following result:

	Spring.	Summer.	Autumn.	Winter.	Year.
Average velocity of all winds in miles, per hour,..	8·16	6·39	6·48	8·91	7·48
Velocity in mean direction, on the supposition that the winds from every point of the compass move with the foregoing velocity,..................	2·72	1·67	2·77	3·82	2·66
True velocity in mean direction, giving to the winds from every point of the compass each their own average velocity, as shown in the table above,..	2·91	1·80	2·70	4·48	2·88
Excess of the latter over the former...............	+ ·19	+ ·13	− ·07	+ ·66	+ ·22

Let the movement of a particle of air be traced, which is supposed to be stirred only by the winds that are found day after day at a given place: at the end of the year the path of the particle, though entirely irregular, will—so far as its progress and general direction are concerned—be essentially the same as the curve more easily formed by joining the four lines, whose direction and length are recorded in the resultants of series I. On the North American coast of the Atlantic the curve is of this general shape ‿⁀, while on the European coast the curvature is reversed, being ⁀‿. The change seems to occur in mid-ocean at longitude 30° to 35° west. Except where there are marked local obstructions to the free flow of the air, this law seems invariable; and it holds in the majority of cases, even in the motion of the clouds; but Mount Washington, New Hampshire, seems a remarkable exception; the observations for 1870–3 give as resultants—

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* Results of Meteorological Observations, 1854–59. Vol. II, Part 1.—United States Senate Document, 36th Congress.

Resultants.		Ratio.	Monsoon influence.	
Spring,	N. 87° 21′ W.	·62	S. 17° 15′ W.	·13½
Summer,	N. 62° 33′ W.	·62	N. 12° 30′ E.	·13
Autumn,	N. 60° 46′ W.	·63½	N. 9° 3′ E.	·15½
Winter,	N. 87° 38′ W.	·60	S. 9° 1′ W.	·13½

These S-shaped curves were pointed out and illustrated by Professor Coffin, in 1848, at the same time that he announced the existence of the Polar system of the northeast winds, and the Temperate system of the westerly winds. The forces that deflect the wind from its mean annual direction, and so cause these peculiar curves are given under the title of Monsoon Influences. Are they due to changes in the temperature, or to variations in atmospheric pressure at the different seasons? An examination of the maps shows instantly that in all parts of the globe, these deflecting forces are inclined toward the nearest adjacent land-center in the summer, and toward the center of the nearest large body of water in the winter, thus showing the direct agency of heat in modifying the direction of the current, and the intensity of its flow. That barometric pressure however plays the more important part in effecting these seasonal changes of direction is shown in Dr. Woeikof's minute discussion; wherein, reproducing the isobaric charts of Dr. Alexander Buchan, he considers the five wind systems in general, and then treats separately the winds in the smaller geographical divisions of the earth. He corrects the error, so generally prevalent, of limiting the monsoons to the tropical part of Asia, showing that they extend as well to all China, Japan, Mantchooria, the western coast of the Sea of Ochotsk, and the basin of the Amoor river; and, with a reverse of seasons, to Australia.

The winds on the whole Atlantic coast of the United States were early shown by Professor Coffin to possess some monsoon features, though slight. The influence of the Gulf of Mexico over the basin of the Mississippi and Ohio, from latitude 34° to 42°, in producing the west-southwest direction of the winds at all seasons, is traced to the constant maximum pressure existing *to the* south and the minimum to the north and northeast.

Dr. Woeikof instances latitude 40° to 60° south as that part of the earth where the winds have the greatest velocity, strong westerly winds prevailing there the whole year: due to the great difference in the pressure of the air at a small distance, or in other words, the steep barometric gradient. As to this topic, Professor Coffin left on record but a few general conclusions, of which we would note only his determination of 65° as the average angle made by the line of the wind's approach, with one drawn to the point of maximum pressure.

The velocity tables, elaborately prepared, mainly from data in the United States, are designed to show the effect of combining the element of velocity with that of time, in computing the resultants. The question is one of vital importance, and the magnitude of the task alone hinders its being solved in a similar manner for all parts of the world. Five years of working time were spent on the reduction of the observations taken at 418 places on the American continent, for a total period of 700 years. The results show that the effect of velocity is to throw the resultant northerly far more frequently than southerly, and at a much greater angle; that it increases its magnitude far more frequently than it diminishes it, and by a greater amount.

In the United States, north of latitude 32°, the annual results obtained by noting the actual velocities average S. 89°+W., with a ratio of ·261; while those had by disregarding the unequal velocities are S. 80°+W., ratio ·227. The divergence is therefore about 9° in the yearly resultants, but greater in winter, and less in summer.

This general fact of a [northerly] divergence and excess of ratio, holds true also for the few places computed, that are situated within the limits of the Polar and Equatorial systems; yet, as the divergence seldom exceeds 15°, the great general conclusions reached must be considered safe, although the variation in velocity be disregarded.

The average velocity, so obtained, of all winds in the United States, is seven miles an hour, being slightly in excess in the northeastern part of the Union, and less in the States nearer the center of the continent.

For positions considered separately, the velocity of the wind is greater—

1. On high isolated peaks, than at low stations,
2. On the seashore, and especially on isolated islands, than in the interior of continents,
3. In level countries, than in countries surrounded by mountains; and
4. In prairies, and especially desert countries, than in wooded regions.

A less velocity than the average belongs to the winds of the equatorial calm-belt, the calm-belts at the polar limits of the trade-winds, and the trade-wind belts.

There is an extensive region in the southwest of the United States, which has a common yearly period of winds, different as are its geographical features. It includes the extreme southeast of California, Arizona, New Mexico, Southern Utah, Texas, Arkansas, the Indian Territory, Eastern Colorado, Eastern Wyoming, Southern Dakota, Nebraska, Iowa, Kansas, and Missouri. The winds are southeast, south, or southwest in summer, with a great ratio of the resultant in the south, diminishing toward the north and east. In winter the winds are mostly north and northwest. This region is equal to more than a million square miles, or about one-third of the United States, without Alaska.

A comparison of the motions of clouds with the mean direction of the surface current, shows that they very nearly coincide in nearly all regions of the United States; the former being more purely west, and having a ratio of resultant of 42 per cent—nearly double that of the surface current, which is 23 per cent—thus showing a steadiness of motion admitting of little monsoon influence; while the lower current has a more west-southwest direction between the Mississippi and the Appalachian chain, and a west-northwest direction in New England.

As the northern and southern boundaries of the great westerly current are approached—at least in the United States—the length of the arrows that designate the cloud current decreases as much below the 42 per cent above named, as they surpass that figure in the center of the aerial stream; and thus the southern limit of this system of cloud motion seems to extend down to north latitude 30°, some three degrees farther south than is assigned to the corresponding system of surface winds.

The work is rich in tabular matter, especially from Spain, Norway, Russia, Siberia and India. Twenty-six charts are attached, in which the general features of the wind systems are delineated, mainly by resultants and wind-roses; the latter bringing into contrast the summer and winter winds. Horary, monthly and annual variation is traced; and one chart exhibits the connection of the wind with fluctuations in the thermometer, amount of cloudiness, and fall of rain and snow. The whole forms a valuable summary of facts in this department of meteorology.

ART. XXXII.—*On some Nitro-derivatives of Diphenylamine;* by DR. PETER TOWNSEND AUSTEN.

A PRELIMINARY notice of the following investigation was published in the Berichte der Deut. Chem. Ges., vol. vii, p. 1248. I had hoped, long before this, to have completed the research in a more satisfactory manner, but my time having been occupied with other subjects, I have but recently been able to return to it.

Pisani[*] found that trinitrochlorbenzol acted on ammonia, and formed trinitroaniline. Clemm[†] applied this reaction to aniline, and obtained a trinitrodiphenylamine. In a similar manner he produced a dinitrodiphenylamine by the action of dinitrobrombenzol on aniline.

The reaction in all of these cases is simple—

$C^6H^2(NO^2)^3Cl$[‡]$+2NH^3=C^6H^2(NO^2)^3NH^2+NH^4Cl$

Several nitro-derivatives of diphenylamine had already been discovered by Hofmann[§] before the research of Clemm was made. They had, however, not been produced by the introduction of a nitrophenyl-complex into aniline, but by the direct nitrition of benzoyldiphenylamine, and subsequent elimination of the benzoyl-group.

The trinitrochlorbenzol was made by Clemm's method; 100 grams of picric acid were well mixed with 200 grams of phosphorous pentachloride, and placed in a large retort connected with an inclined condenser. On heating gently, the mass began to fuse, on which the burner was taken away. The reaction proceeds by itself and is very violent. After the ces-

[*] Ann. Chem. Pharm., xcii, 326.

[†] Jour. Pr. Chem. [II], i, 145.

[‡] On the ease of substitution of haloid atoms in nitro-compounds, see my Einleitung zu den aromatischen Nitroverbindungen, page 8. "Chlorbenzol lässt beim Behandeln mit alkoholischem Ammoniak unter keinen Umständen sein Chloratom durch die Amidogruppe substituiren. Chlormononitrobenzol aber bei erhöhter Temperatur; Chlordinitrobenzol bei 100°; während Chlortrinitrobenzol schon in der Kälte energisch auf Ammoniak wirkt. Aus diesen, wie aus zahlreichen andern ähnlichen Thatsachen, ziehen wir die Schlussfolgerung, dass die Nitrogruppe die Anziehung der andern negativen Atome lockert. (Vergleiche auch Salkowski (Ber. Chem. Ges., vi, 141), Engelhardt und Latschinoff (Zeit. Chem., 1870, 225), Walker und Zincke (Ber. Chem. Ges., v, 114).)"

"Umgekehrt dürfen wir voraussetzen, dass dieselbe die Anziehung der positiven Gruppen des Moleküls verstärken müsse. Dass diese Voraussetzung richtig ist, geht aus dem Verhalten der Amidogruppe hervor. Behandelt man Anilin mit Amylnitrit, so ist die Einwirkung sehr heftig, bei Nitroanilin weniger, bei Dinitroanilin sehr ruhig, während Trinitroanilin keine Reaction giebt." According to Körner (Jahresbericht, 1875, 365), however, the weakening action of the nitro-group on halogens is only exerted when the relation is 1·2 or 1·4, not extending, however, to 1·3.

[§] Ann. Chem. Pharm., cxxxii, 160.

sation of the action, most of the phosphorous oxychloride was distilled off. The heavy red liquid, remaining in the retort, was poured into a large excess of cold water and violently stirred. After the phosphorous oxychloride had been entirely decomposed by the water, and the mass had solidified, the impure substance was well washed with water, powdered, and extracted with ether by means of a filter pump. A dark-red resin was by this means removed. The bright yellow powder, left on the filter, was dissolved in boiling absolute alcohol and purified by animal charcoal.

In this manner beautiful bright yellow crystals of trinitrochlorbenzol were obtained. By drying they became darker. The yield is from 30–40 per cent.

I obtained better results, however, by simply heating the substances in a high beaker glass, for I found that a considerable amount of the chlorpicryl was destroyed during the distillation of the phosphorous oxychloride. I found, also, that the yield was far better, when instead of 100 grams of picric acid and 200 grams of phosphorous pentachloride, 50 grams of picric acid and 100 grams of phosphorous pentachloride were taken. By this method the conversion of the picric acid into chlorpicryl, the decomposition of the phosphorous oxychloride, the extraction with ether, and the crystallization from alcohol, all together do not take more than an hour.

The trinitrochlorbenzol fused at 82·5°–83°. By dissolving it in glacial acetic acid, diluting the solution with water, and allowing it to stand, superb feathers, frequently over two inches in length, were obtained.

Alphatrinitrophenylmetanitraniline.[*]

Preparation.—25 grams of metanitraniline (112°) and 27 grams of chlorpicryl were dissolved in boiling absolute alcohol. On boiling the solution for a few minutes, the separation of a heavy yellow crystalline sand began. This sand was not redissolved by addition of more alcohol. The solution was allowed to cool, the precipitate separated by filtration, purified by crystallization from glacial acetic acid, dried at 100°, and analyzed.

Analysis.—A combustion[†] gave—

0·2744 grms. of substance burned with lead chromate gave 0·414 grms. of CO^2 and 0·582 grms. of H^2O.

0·2752 grms. of substance gave V=48·8 c.c. [B=764·8 mm.; *t*=21·5°].

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[*] The trinitrophenyl-complex of picric acid is in this research distinguished by the prefix *alpha*. The relation is most probably para, but it requires experimental demonstration. (Compare Gnehm. Inaug. Diss.)

[†] The large number of nitro-groups present in these compounds rendered the use of an unusual amount of copper spirals necessary.

he formula $$N\left\{\begin{array}{l} C^6H^4(NO^2)_m \\ C^6H^2(NO^2)^3\,a = C^{12}H^7N^5O^8 \\ H \end{array}\right.$$

Calc.	Found. I.	II.
C=41·20	41·15	....
H= 2·00	2·36	....
N=20·05	....	20·33

he mother liquor contained the nitraniline chlorhydrate. nitraniline was precipitated by sodium hydrate and, after fication, used again.

he reaction is exactly analogous to the one representing formation of trinitroaniline (loc. cit.).

$${}^{2}(NO^{2})^{3}Cl + 2C^{6}H^{4}(NO^{2})NH^{2} = N\left\{\begin{array}{l} C^{6}H^{4}(NO^{2}) \\ C^{6}H^{2}(NO^{2})^{3} \\ H + C^{6}H^{4}(NO^{2})NH^{2}\cdot HCl \end{array}\right.$$

olubility.—Almost entirely insoluble in hot water, coloring it ow, however: hardly soluble in boiling ether, carbon disulle, carbon tetrachloride, chloroform, and absolute alcohol. luble in chlorhydric, nitric (dil.) and sulphuric (dil.) acids. ly soluble in concentrated sulphuric acid to a deep red wine r, and is separated unchanged in the form of yellow flocks he addition of water. In aniline it is easily soluble with a tiful red color. In hot amyl-alcohol it is easily soluble, crystallizes badly therefrom. In hot glacial acetic acid it asily soluble, and separates in the form of a beautiful ge-red crystalline sand. From a solution in acetylchloride ystallizes in small wine-yellow transparent crystals.

queous ammonia dissolves it very easily, the solution ning a splendid scarlet-red color. By evaporation it rates unchanged. In weak aqueous solutions of alka- it behaves as with ammonia. Concentrated solutions of um and potassium hydrates, especially by heating, decom- it with evolution of ammonia.

roperties.—The compound consists of a heavy, crystalline, ow sand, fusing at 205° to a red liquid which, when undised, solidifies at about 175°. By careful heating it vola-s in the form of a yellow powder. It burns with a yellow nous flame when heated on a platinum foil, and leaves a us coal. If it be thrown on a hot surface it explodes like owder. By percussion it is not explosive.

Alphatrinitrophenylparanitraniline.

reparation.—This compound was made in a manner similar to receding one. Paranitraniline (made by nitrition of acetani- elimination of the acetyl-group by boiling with concen- d chlorhydric acid, and decomposition of the nitraniline hydrate by sodium hydrate) with the calculated amount of picryl chloride was brought into solution in boiling absolute alcohol. On continuing the boiling, a red crystalline powder separated.

Analysis.—The substance was purified by crystallization from glacial acetic acid, dried at 100°, and analyzed.

0·2888 grms. of substance burned with lead chromate gave 0·4354 grms. of CO^2 and 0·5920 grms. of H^2O.

0·2852 grms. of substance gave $V=49{\cdot}8$ c.c. [$B=767$mm.; $t=23°$].

The formula $N\left\{\begin{array}{l} C^6H^4(NO^2)_p \\ C^6H^2(NO^2)^3{}_a \\ H \end{array}\right. = C^{12}H^7N^5O^8$

Calc.	Found. I.	Found. II.
$C=41{\cdot}26$	41·12	....
$H=2{\cdot}00$	2·27	....
$N=20{\cdot}05$	....	20·07

Solubility.—The solubility of this compound is nearly the same as the preceding one, being, in general, somewhat higher. In aqueous ammonia it is easily soluble to a red color. Acids precipitate it unchanged from this solution. From alcoholic ammonia it crystallizes in beautiful glittering leaves.

It dissolves in a warm solution of sodium carbonate to a scarlet-red color. On cooling, violet needles separate. This, without doubt, is the sodium salt of the alphapicrylparanitraniline, $N\left\{\begin{array}{l} C^6H^4(NO^2)_p \\ C^6H^2(NO^2)^3{}_a \\ Na \end{array}\right.$ The needles are soluble in alcohol and water, and are decomposed by acids.

It is insoluble in an aqueous solution of ammonium carbonate. Easily soluble in amyl alcohol, crystallizing therefrom in bright, glittering, yellow scales. In aniline it dissolves easily, and separates on evaporation in a crystalline form. It is also quite soluble in benzoyl chloride, acetyl chloride, benzyl chloride and chlorbenzol.

Properties.—In general this compound seems to possess more acid properties than its isomer. The pure substance fuses at 216°.

Dinitrophenylmetanitraniline.

Preparation.—Calculated amounts of dinitrobrombenzol (produced by nitrition of brombenzol) and metanitraniline were rubbed to a pap with absolute alcohol, and the mixture heated twenty hours at 100° in a closed tube. The reaction took place in the most satisfactory manner.

On cooling, the tube contained hard brown crystals. They were washed on a filter with warm alcohol until the filtrate contained no trace of nitraniline chlorhydrate.

Analysis.—The substance was purified by repeated crystallization from an excess of glacial acetic acid, dried at 100°, and analyzed.

0·2780 grms. of substance burnt with lead chromate gave 0·0896 grms. of H^2O and 0·4844 grms. of CO^2.

0·2822 grms. of substance gave V=46 c.c. [B=757·2 mm.; *t*=22·2°].

The formula $N\begin{cases} C^6H^4(NO^2)_m \\ C^6H^3(NO^2)^2{}_p \\ H \end{cases}=C^{12}H^8N^4O^6$

Calc.	Found. I.	Found. II.
C=47·36	47·81	....
H= 2·63	3·57	....
N=18·42	....	18·66

Solubility.—The substance is insoluble in water, alcohol and ether. Difficultly soluble in boiling glacial acetic acid. It is soluble in an excess of boiling chloroform, separating in small yellow crystals.

Properties.—Small glittering yellow crystals, fusing at 189°* to a red liquid. With alkalies it behaves in the same manner as the trinitrophenylparanitraniline.

Dinitrophenylparanitraniline.

Preparation.—The calculated amounts of dinitrobrombenzol and paranitraniline were treated as in the production of the preceding compound. On cooling the tube contained a mass of dark-red crystals. They were washed with dilute alcohol.

Analysis.—As the substance did not crystallize from any solvent, it was purified by solution in glacial acetic acid and precipitation by water. In this manner, bright yellow flocks were obtained. After three repetitions of the solution, precipitation, and washing, the substance was dried at 100° and analyzed.

0·3080 grms. of substance burnt with lead chromate gave 0·5386 grms. of CO^2 and 0·0912 grms. of H^2O.

0·2348 grms. of substance gave V=37·6° [B=755·3 mm.; *t*=19°].

The formula $N\begin{cases} C^6H^4(NO^2)_p \\ C^6H^3(NO^2)^2{}_p \\ H \end{cases}=C^{12}H^8N^4O^6$

Calc.	Found. I.	Found. II.
C=47·36	47·68	....
H= 2·63	3·29	....
N=18·42	....	18·29

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* Wilgerodt announced (in Ber. Chem. Ges., ix, 1178) a dinitrophenylmetaniraniline which he had produced by the action of *a* $C^6H^3(NO^2)^2Cl$ on metaniraniline. This is perhaps identical with my compound, although he finds a using point of 194–5°.

Solubility.—The substance is *easily soluble in cold glacial acetic acid.* It here shows a striking difference from the dinitrophenylmetanitraniline which is *difficultly soluble in boiling glacial acetic acid.* It is difficultly soluble in cold absolute alcohol, easily in hot.

Properties.—The compound forms a light-yellow and extraordinarily light, elastic and electric powder. It fuses at 181°. Owing to the small amount of the substance at my disposal, I have not been able to investigate its properties more thoroughly.

Since the picrylnitranilines contain the mononitrophenyl-group, it appeared extremely probable to me that a further nitrition could be effected. In this case, since the trinitrophenyl-group seems to be the limit of direct nitrition of the phenyl-group, I could predict* that by the nitrition of the picrylnitranilines, higher nitro-members would be formed, and that the nitro-groups would enter into the mononitrophenyl-group. If, then, by the nitrition of the picrylnitranilines, higher isomeric nitro-compounds were obtained, the isomerism must reside in the nitrized mononitrophenyl-group, since the trinitrophenyl-group remains unchanged during the nitrition.†

It is, however, very possible that in *one* of the resulting compounds the two picryl-groups may be identical.

Since the positions of the nitro-groups in these dipicrylamines has not been ascertained, I shall represent the trinitrophenyl-group of picric acid by α, and the dinitromononitrophenyl-groups of meta and paranitraniline by β and γ respectively. Only two of these picryl-groups can be identical.

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* Supposing that the imido-group would withstand the action of the nitrous acid.

† That is, we suppose it does. The supposition will doubtless remain synonymous with the fact for some time to come. Picric acid remains unchanged by the action of nitrizing agents. Hence we suppose that this trinitrophenyl-group when combined in the picrylnitraniline also remains unaltered during nitrition. I have no proof, however, that the introduction of two nitro-groups into the mononitrophenyl-group does not exert a displacing action on the members of the picryl-group.

In nitrizing the paradibrombenzol, I find that the relative amounts of isomers formed are not constant. This seems to depend on the strength and the amounts of the acids used as well as on the duration and temperature of the heating. I am, at present, endeavoring to determine this more exactly, in the hope of being able to produce more of a given isomer at will.

An interesting field is opening in regard to whether several isomers are formed at once, or whether one is formed first and the others from it by atomic migration. If the latter is the case, then the production of relative amounts of isomers is partly under control. In this connection it is interesting to remark that Doer (Ber. Chem. Ges., v, 795. Compare Hlasiwetz, Wien. Acad. Ber., xxiv, 237) by nitrition of diphenylmethane obtained a dinitro-compound, while by continued digestion of the nitrition mixture he got an isodinitro-compound. 1·4 nitrophenol is formed in the cold, the 1·2 compound, however, by heating (Jahresbericht, 1875, 364).

Alphapicrylbetapicrylamine.

Preparation.—The alphapicryl-metanitraniline was added in small portions to a cooled mixture of equal volumes of fuming nitric and concentrated sulphuric acids. The liquid became hot, and a violent reaction set in. After the reaction had subsided, the liquid was poured into cold water. A bright sulphur-yellow cream was in this manner obtained. If, however, the acid solution is boiled for half an hour, the substance is completely destroyed, and, on pouring the liquid into water, only a resin is obtained.

After washing out the acid with water, the cream was well extracted with alcohol, by which means a resin, giving a deep orange-red solution, was removed. The substance was then dissolved in boiling glacial acetic acid, and precipitated by concentrated chlorhydric acid, well washed with dilute chlorhydric acid, dissolved again in boiling glacial acetic acid, boiled some time with animal charcoal, filtered, and allowed to crystallize.

Analysis.—A portion of the substance was purified by crystallization from glacial acetic acid, dried at 100°, and submitted to analysis.

0·2876 grms. of substance gave 0·3490 grms. of CO^2 and 0·0404 grms. of H^2O.

0·2924 grms. of substance gave 0·3538 grms. of CO^2 and 0·0404 grms. of H^2O.

The formula $N \left\{ \begin{array}{l} C^6H^2(NO^2)^3{}_\beta \\ C^6H^2(NO^2)^3{}_\alpha = C^{12}H^5N^7O^{12} \\ H \end{array} \right.$

Calc.	Found. I.	Found. II.
C=32·8	33·09	32·99
H=1·13	1·56	1·53

Solubility.—It is almost insoluble in hot water, coloring it, however, slightly yellow. Chlorhydric, nitric and sulphuric acids do not increase its solubility in water. In hot amyl and ethyl alcohols it is almost insoluble, hardly soluble in ether, carbon tetrachloride, carbon disulphide, and chloroform. In cold glacial acetic acid, difficultly soluble, in the hot acid, it dissolves easily. In aniline, it is easily soluble.

In aqueous ammonia, sodium and potassium hydrates, it dissolves easily with a superb scarlet color.

Properties.—Impalpable bright sulphur-yellow powder. By careful crystallization from glacial acetic acid, it can be obtained in small transparent glittering crystals. It fuses at 261° to a red liquid, which at 175°–170° solidifies to a red glass. By touching it with a hard object when in a liquid state, it solidifies to a yellow amorphous mass.

Vapors of ammonia turn it scarlet. By boiling with moderately concentrated solutions of sodium and potassium hydrates, it decomposes with evolution of ammonia. In an aqueous solution of sodium carbonate it dissolves easily, forming the sodium salt.

By addition of water to the boiling glacial acetic acid solution, a thick precipitate is formed, which, after crystallization from glacial acetic acid, showed a fusing point of 205°, and on analysis proved to be the original picrylmetanitraniline from which this dipicrylamine had been prepared. *By the addition, then, of water, to the boiling solution in glacial acetic acid, the alphabetadipicrylamine loses two nitro-groups and is converted back into the picrylmetanitraniline.*

The dipicrylamine does not explode by percussion. If heated, it puffs with a white luminous flame, and leaves a light porous coal. It explodes with violence when thrown on a hot platinum foil.

Alphapicrylgammapicrylamine.

Preparation.— This compound was prepared by nitrition of the picrylparanitraniline in the same manner as in the case of the preceding compound. On pouring the resulting mixture into cold water, the substance separated as a light greenish-yellow cream. After extraction with alcohol it was crystallized from glacial acetic acid, dried at 100°, and analyzed.

Analysis.—

0·2836 grms. of substance burnt with lead chromate gave 0·3480 grms. of CO^2 and 0·0436 grms. of H^2O.

0·2792 grms. of substance gave V=54·3c.c.[B=756^{mm}; *t*=22°].

$$\text{The formula } N\begin{cases} C^6H^2(NO^2)^3{}_\gamma \\ C^6H^2(NO^2)^3{}_a = C^{12}H^5N^7O^{12} \\ H \end{cases}$$

Calc.	Found.	
	I.	II.
C=32·80	32·08	....
H= 1·13	1·70	....
N=22·32	....	21·91

Solubility.—The solubility is about the same as that of the preceding compound.

Properties.—Small transparent glittering light-yellow prisms with a green reflex. It fuses at 230° with effervescence and decomposition. It puffs on being heated, and explodes with violence when thrown on a hot surface. With alkalies, it behaves like the alphabeta-compound.

I have already mentioned that these compounds, particularly the dipicrylamines, give fine scarlet colors with alkalies.

According to Hofmann, the mono- and dinitrophenylamines give similar ones. This fact was substantiated by Clemm.

I find that these colors are caused by the formation of salts of the nitrodiphenylamines. The hydrogen atom of the imido-group has become so negative by the introduction of the nitro-groups, that it can easily be substituted by basic atoms. It reacts easily, indeed, with carbonates of the alkalies.

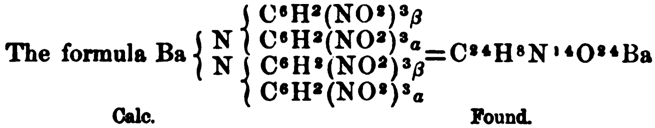
Of the numerous salts of these compounds which I have prepared, I have as yet had time only to investigate one—the barium salt of the alphabetadipicrylamine.

Barium-alphapicrylbetapicryldiamine.

Preparation.—The $\alpha\beta$-picrylamine was added to an aqueous soap of barium hydrate (or carbonate). The dipicrylamine dissolved immediately with a deep intense red color. The solution was boiled for a few minutes and then evaporated on a water-bath. After a sufficient concentration had been obtained, the solution was allowed to stand. A beautiful crystallization of dark-red needles was obtained. They were purified by repeated crystallization from water.

Analysis.—A portion of the needles were dried at 100° and mixed with sodium carbonate and nitrate. Some sodium carbonate was then fused in a platinum crucible, and the mixture added to it in small portions. The resulting solution was kept n fusion about five minutes, and then allowed to cool. After t had become quite cold it was dissolved in very dilute chlorhydric acid, filtered, the solution brought to boiling, and precipitated with sulphuric acid.

0·4012 grms. of substance gave 0·0908 grms. of $BaSO^4$.



$$\text{The formula } Ba\left\{\begin{matrix}N\\N\end{matrix}\right.\begin{matrix}\left\{\begin{matrix}C^6H^2(NO^2)^3{}_\beta\\C^6H^2(NO^2)^3{}_\alpha\end{matrix}\right.\\\left\{\begin{matrix}C^6H^2(NO^2)^3{}_\beta\\C^6H^2(NO^2)^3{}_\alpha\end{matrix}\right.\end{matrix}=C^{24}H^8N^{14}O^{24}Ba$$

Calc.	Found.
Ba=13·52	13·30

The reaction by which this barium salt is formed is very simple:

$$2(NH[C^6H^2(NO^2)^3]^2)+Ba(OH)^2=Ba[N(C^6H^2(NO^2)^3)^2]^2+H^2O$$

Solubility.—Quite easily soluble in boiling water, less so in alcohol.

Properties.—Small, dark saffron-red glittering needles. It seems to have enough basic properties to form salts with weak acids. This interesting fact I hope shortly to prove. If t be brought into a flame, it explodes in a remarkable manner, flying through the air with brilliant coruscations, and giving a beautiful barium-flame. Thrown on a hot surface it explodes with great violence.

With the hydrates and carbonates of the metals, the dipicrylamine yields in the same manner fine salts.

The most beautiful salt which I have yet obtained is the ammonium-alphagammapicrylamine. It crystallizes in superb intense red transparent rhombohedrons (?). Whether it is identical or only isomeric with the dyestuff "Aurantia," which is now produced on a large scale, I have not had an opportunity of ascertaining.

By treatment of the sodium salts of the dipicrylamines with picrylchloride, a reaction takes place doubtless with the formation of the tertiary picrylamine, $N(C^6H^2(NO^2)^3)^3$.

Immediately after the publication of my preliminary notice, Gnehm* announced some new nitrodiphenylamines which he had obtained by nitrition of methyldiphenylamine, the methyl-group having been eliminated during the operation.†

The following table will show the various nitrodiphenylamines known, their method of preparation, and properties.

No.	Rational Formula.	Empirical Formula.	Remarks.
I.	$N\left\{\begin{array}{l}C^6H^5\\ C^6H^4(NO^2)\\ CO.C^6H^5\end{array}\right.$	$C^{19}H^{14}N^2O^3$	Hofmann, HNO^3 on $N\left\{\begin{array}{l}(C^5H^5)^2\\ CO.C^6H^5\end{array}\right.$ Light-yellow crystals.
II.	$N\left\{\begin{array}{l}C^6H^5\\ C^6H^4(NO^2)\\ H\end{array}\right.$	$C^{12}H^{10}N^2O^2$	Do., NaOH on No. I.
III.	$N\left\{\begin{array}{l}C^6H^4(NO^2)\\ C^6H^4(NO^2)\\ CO.C^6H^5\end{array}\right.$	$C^{19}H^{13}N^3O^5$	Do., fuming HNO^3 on $N\left\{\begin{array}{l}(C^6H^5)^2\\ CO.C^6H^5\end{array}\right.$ Deep yellow crystalline substance.
IV.	$N\left\{\begin{array}{l}C^6H^4(NO^2)\\ C^5H^4(NO^2)\\ H\end{array}\right.$	$C^{12}H^9N^2O^4$	Do., NaOH on No. III. Red yellow needles with metallic blue reflex.
V.	$N\left\{\begin{array}{l}C^6H^5\\ C^6H^3(NO^2)^2{}_m\\ H\end{array}\right.$	$C^{12}H^9N^3O^4$	Clemm, $C^6H^3(NO^2)^2Br$ on $C^6H^5NH^2$. Long thin scarlet-red or red-yellow glittering needles. Fuses at 153°. Wilgerodt, a-$C^6H^3(NO^2)^2Cl$ on alcoholic H^2S-solution of aniline. Fuses at 156°–157°

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* Ber. Chem. Ges., vii, 1399.

† The elimination of a group during nitrition is quite frequent. Tribrommethyldiphenylamine gives dibromtetranitrodiphenylamine [Gnehm] (Ber. Chem. Ges., viii, 930): tetrahydroisoxyloldicarboxyl (camphoric acid) yields trinitroisoxylol, under elimination of hydroxyl and carboxyl [Wreden] (ibid., v, 1106): many sulphonic acids part with the sulpho-group during nitrition. Cresolsulphonic acid gives trinitrocresol [Duclos] (Ann. Chem. Pharm., cix, 135) and dinitrocresol [Armstrong and Field] (Chem. News, xxvii, 318); dichlorphenolsulphonic acid yields a nitrochlorphenol [Armstrong] (Chem. Soc. Jour. [2], ix, 1112): monochlorphenolsulphonic acid, from solid chlorphenol, gives dinitrochlorphenol [Petersen and Baehr-Predari] (Ann. Chem. Pharm., clvii, 121): the monochlorphenolsulphonic acid from liquid chlorphenol behaves in a similar manner [Armstrong and Prevost] (Ber. Chem. Ges., vii, 404): sulphopodocarpinic acid yields dinitropodocarpinic acid [Oudemans] (ibid., vii, 1317). By nitrition of benzoylnaphthylamine, Hübner and Ebell (Ann. Chem. Pharm., clxx, 212) think they obtained a small amount of nitronapthylamine. In the nitrition residues of diphenyl, Fittig (ibid., cxxiv, 275) *detected* small amounts of nitrobenzol.

	$N\left\{\begin{matrix}C^6H^5\\C^6H^2(NO^2)^3{}_a\\H\end{matrix}\right.$	$C^{12}H^8N^4O^6$	Do., $C^6H^2(NO^2)^3Cl$ on $C^6H^5NH^2$. Sparkling prisms. By reflection scarlet-red; by refraction reddish-yellow. Fuses at 175°.
	$N\left\{\begin{matrix}C^6H^4(NO^2)_m\\C^6H^3(NO^2)^2{}_m\\H\end{matrix}\right.$	$C^{12}H^8N^4O^8$	Austen, $C^6H^3(NO^2)^2Br$ on *m*-nitraniline. Small glittering yellow crystals. Fuses at 189°.
I.	$N\left\{\begin{matrix}C^6H^4(NO^2)_p\\C^6H^3(NO^2)^2{}_m\\H\end{matrix}\right.$	$C^{12}H^8N^4O^6$	Do., $C^6H^3(NO^2)^2Br$ on *p*-nitraniline. Light electrical yellow powder. Easily soluble in cold glacial acetic acid. Fuses at 181°.
	$N\left\{\begin{matrix}C^6H^4(NO^2)_m\\C^6H^2(NO^2)^3{}_a\\H\end{matrix}\right.$	$C^{12}H^7N^5O^8$	Do., $C^6H^2(NO^2)^3Cl$ on *m*-nitraniline. Heavy cryst. yellow sand, or wine-yellow transparent crystals. Fuses at 205°.
	$N\left\{\begin{matrix}C^6H^4(NO^2)_p\\C^6H^2(NO^2)^3{}_a\\H\end{matrix}\right.$	$C^{12}H^7N^5O^8$	Do., $C^6H^2(NO^2)^3Cl$ on *p*-nitraniline. Red crystalline powder, or glittering scales. Fuses at 216°.
	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\beta\\C^6H^2(NO^2)^3{}_a\\H\end{matrix}\right.$	$C^{12}H^5N^7O^{12}$	Do., nitrition of IX. Fuses at 261°. Impalpable bright yellow powder or small transparent glittering yellow crystals.
	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\gamma\\C^6H^2(NO^2)^3{}_a\\H\end{matrix}\right.$	$C^{12}H^5N^7O^{12}$	Do., nitrition of X. Small transparent glittering bright yellow prisms with green reflex. Fuses at 230°
	$Ba\left\{\begin{matrix}N\left\{\begin{matrix}C^6H^2(NO^2)^3{}_\beta\\C^6H^2(NO^2)^3{}_a\end{matrix}\right.\\N\left\{\begin{matrix}C^6H^2(NO^2)^3{}_\beta\\C^6H^2(NO^2)^3{}_a\end{matrix}\right.\end{matrix}\right.$	$C^{24}H^8N^{14}O^{24}Ba$	Do., $Ba(OH)^2$ on XI. Dark saffron-red glittering needles. Explodes on heating.
	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\,?\\C^6H^2(NO^2)^3\,?\\H\end{matrix}\right.$	$C^{12}H^5N^7O^{12}$	Gnehm, nitrition of diphenylamine. Transparent light-yellow prisms. Fuses at 238°.
	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\,?\\C^6H^2(NO^2)^3\,?\\NH^4\end{matrix}\right.$	$C^{12}H^8N^8O^{12}$	Do., NH^3 on XIV. Beautiful red leaves.
	$N\left\{\begin{matrix}C^6H^2Br{\cdot}NO^2)^2\,?\\C^6H^2Br(NO^2)^2\,?\\H\end{matrix}\right.$	$C^{12}H^5N^5Br^2O^8$	Do., nitrition of $HN\left\{\begin{matrix}C^6H^4Br\\C^6H^3Br^2\end{matrix}\right.$. Yellow pearly leaves or rhombic tablets. Fuses at 235°–240°–242°.
I.	$N\left\{\begin{matrix}C^6H^2(NO^2)^2Br\,?\\C^6H^5\\H\end{matrix}\right.$	$C^{12}H^8N^3BrO^4$	Austen, $C^6H^5.NH^2$ on $C^6H^2\left\{\begin{matrix}(NO^2)^2{}_\beta\\Br^2{}_p\end{matrix}\right.$ Beautiful red-orange, fine hairy needles. Fuses at 120°. (This Journal, xii, 118.)
II.	$N\left\{\begin{matrix}C^6H^2(NO^2)^2Br\,?\\C^6H^3(NO^2)^2\,?\\H\end{matrix}\right.$	$C^{12}H^5N^5BrO^8$	Do., nitrition of XVII. Small brown scales. Fuses at 167·5°.
	$N\left\{\begin{matrix}C^6H^3(NO^2)^2\,?\\C^6H^4.C^6H^4.NH^2\,?\\H\end{matrix}\right.$	$C^{18}H^{14}N^4O^4$	Wilgerodt, *a*-$C^6H^3(NO^2)^2Cl$ on benzidine. Short bluish brown-red needles. Fuses at 255°. (Ber. Chem. Ges., ix, 977.)
	$N\left\{\begin{matrix}C^6H^3(NO^2)^2\,?\\C^6H^4.C^6H^4.NH\;C^6H^3[(NO^2)^2\\H\end{matrix}\right.$	$C^{24}H^{16}N^6O^8$	Do., formed with XIX. Yellow pulverulent. Sol. in conc. H^2SO^4 with a violet color. Fuses at 330°.
	$N\left\{\begin{matrix}C^6H^3(NO^2)Clm\\C^6H^5\\H\end{matrix}\right.$	$C^{12}H^9N^2ClO^2$	Laubenheimer. Action of $C^6H^3(NO^2)Cl^m$. NO^2 on aniline. Long glittering alizarine-red needles. Fuses at 108·5°.

niversity Laboratory of Berlin, August 30, 1876.
chool of Mines, New York, January 3, 1877.)

ART. XXXIII.—*Note on Mineral Analysis; Notes upon some Fluorides; and Note on Molecular Volumes;* by F. W. CLARKE, S.B., Professor of Physics and Chemistry.—*Laboratory Notes from the University of Cincinnati.* Nos. I to III.

I. *Note on Mineral Analysis.*

IN 1868,* the writer called attention to the fact that certain very refractory minerals are easily rendered soluble by fusion with a mixture of sodium fluoride and acid potassium sulphate. He now finds that in many cases, and with but little loss of power, common salt may replace the fluoride, the mode of manipulation remaining the same. The finely pulverized mineral is to be mixed with three parts of the chloride in a capacious platinum crucible, and the mixture covered with twelve or fifteen parts of the acid sulphate in small fragments. The fusion is then performed over an ordinary Bunsen's flame, and in five or six minutes is complete. The fused mass, after cooling, detaches readily from the crucible, and shows upon its smooth under surface no traces of undecomposed assay.

This method is not by any means equal to the original process with sodium fluoride, either in speed or in generality of application; still, in some cases, it is convenient. Sodium fluoride is expensive, and not always immediately to be obtained; hence the desirability of a substitute. Perhaps my new observation might better be stated thus: that whenever a mineral is resolvable by fusion with the acid sulphate alone, the action is very much facilitated by the addition of common salt.

The new fusing mixture will probably prove to be most serviceable in the analysis of refractory iron ores and of chromite. The latter mineral, after fusion with chloride and bisulphate, furnishes a green mass completely soluble in dilute hydrochloric acid. Or this mass may be treated directly with strong nitric acid and potassium chlorate, after the method of Storer and Pearson, and all the chromium oxidized at once to chromic acid. Precipitation of the chromium as mercurous chromate is then possible, but not wholly convenient. Several unsuccessful efforts were made to carry out the oxidation of the chromium in the course of the fusion itself. With the sodium fluoride or chloride, sodium nitrate or potassium chlorate was mixed. Then upon fusing with the acid sulphate, partial oxidation ensued, but in no case did more than a small fraction of the chromium seem thus to be affected.

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* This Journal, March, 1868.

II. *Notes upon some Fluorides.*

Nickel fluoride.—This salt was prepared by dissolving nickel ydrate in aqueous hydrofluoric acid. Upon concentrating the ark green fluid a granular mass of crystals separated out; which, ccording to water determinations made by Mr. John Hagemann, ad the composition $NiF_2.3H_2O$. The last portions of water ere retained up to the temperature of 130°. Percentage of water ound, 35·98; calculated, 35·81. Specific gravity, 2·014 at 19°. he anhydrous fluoride, NiF_2, had the density 2·855 at 14°. hese specific gravity determinations were made in an ordinary pecific-gravity bottle, chloroform being the liquid employed.

On two accounts these observations are interesting. First, ecause the hydrated salt is evidently new, the crystallized ickel fluoride described by Berzelius having contained but wo molecules of water. Secondly, the molecular volume of e water in this new hydrate is 13·65; corresponding very losely with the average value of 13·76, deduced by the writer om the study of over thirty different salts, and stated in his aper of two years ago.*

Attempts to prepare a double fluoride of nickel and silver et with but indifferent success. In several experiments the ixed solutions of the two fluorides yielded upon concentrating nly the nickel salt alone; the silver compound apparently ecomposing. In one instance, however, pale apple-green eedles were deposited, mixed with some microscopic rhomboedrons. Upon recrystallizing, about two-tenths of a gram of hese crystals were obtained, both forms being represented, and, o the naked eye, both consisting of one and the same substance. qualitative examination showed them to be a true double uoride of nickel and silver, highly hydrated; but not sufficient n quantity for a thorough analysis. The silver in them mounted to a trifle less than twenty per cent, a proportion hich agrees with no probable formula.

Zinc fluoride.—The only new fact for me to record concerning his salt is its density. Two distinct samples of the crystallized ompound, $ZnF_2.4H_2O$, obtained from a solution of zinc in ydrofluoric acid, gave respectively 2·567 at 10°, and 2·535 at 2°. The anhydrous fluoride gave in one experiment a speific gravity of 4·556 at 17°, and in another 4·612 at 12°. hese figures are noticeable from the fact that they do not gree with the usual molecular volume of water of crystallizaion. They yield a volume of water ranging from 11·4 to 11·8; n amount considerably below the usual value. I will not now azard any conjectures as to the meaning of this apparent xception.

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* This Journal, December, 1874.

The writer has also determined the specific gravities of several alkaline fluorides, as follows: Lithium fluoride, 2·295, 21·5°; sodium fluoride, 2·558, 14·5°: potassium fluoride, 2·096, 21·5°. According to Bödeker, potassium fluoride has a density of 2·454 at 12°. Theoretical considerations, to be cited in the third part of this paper, sustain the lower value as obtained by me. An examination of rubidium fluoride, made upon a very small quantity of material. may not prove to be wholly trustworthy. It gave a specific gravity of 3·102 at 17°. Rubidium carbonate was dissolved in hydrofluoric acid. the solution evaporated to dryness in a platinum dish, and the residue fused at a heat just below redness. The molten fluoride was so transparent as to be almost invisible in the vessel containing it: but, upon cooling, it became white and opaque, and contracted so strongly as to split up into several fragments. This salt is extremely deliquescent.

Attempts to prepare fluorides of gold and platinum were wholly unsuccessful. Still, results were obtained which may be worth recording. To a solution of gold chloride, silver fluoride was added, in order that by double decomposition silver chloride might be thrown down and gold fluoride formed. In fact, however, there fell a pale-brown precipitate which grew rapidly darker in color, and which consisted of silver chloride mixed with gold oxide. The reaction may be expressed as follows:

$$2AuCl_3+6AgF+3H_2O=Au_2O_3+6AgCl+6HF.$$

With platinum tetrachloride and silver fluoride a pale-yellow precipitate was formed, containing platinum dioxide, thus:

$$PtCl_4+4AgF+2H_2O=PtO_2+4AgCl+4HF.$$

The same precipitates are formed when silver nitrate is used instead of fluoride, nitric acid being set free in place of hydrofluoric. This has long been known, the reactions being new only in so far as they involve the effect of silver fluoride. This statement is made so that perhaps some other investigators may be saved from tedious and fruitless experimenting.

III. *Note on Molecular Volumes.*

Several years ago, in a series of papers upon atomic or molecular volumes, I pointed out some curious multiple relations connecting both elements and compounds.* For example, I found that a simple relation of this kind connected the alkaline metals with each other; and, later, that the haloid salts of some of these metals had molecular volumes multiples of that of hydrogen. For this latter relation, however, my materials were meager. I had then the specific gravity determinations

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* This Journal, March and May, 1869; September, 1870.

Cl, NaCl, KCl, NaBr, KBr, NaI, and KI, or seven com- ls in all. To these I added, though unsatisfactorily, the ponding salts of silver, making a list of ten bodies closely l, and giving volumes multiples of 5·5, the value assigned ›pp to hydrogen in its liquid compounds, at their boiling ʟ This relation I am now able to extend, partly by new ;y observations of my own, to include at least twelve ›unds not in my earlier list.

own determinations, in addition to those I have already for the alkaline fluorides, are as follows: Rubidium de, 2·209, 19°; rubidium bromide, 2·780, 17·5°; rubidium ·, 3·023, 22°; lithium bromide, 3·102, 17°; lithium iodide, 23°.

w let us tabulate the material. The first column contains 'mbol of the substance, the second its density with author- ven, the third its molecular volume as found, the fourth lume calculated, the fifth a theoretical density deduced this volume. The calculated volumes are of course the multiples of Kopp's hydrogen value, and will be seen at ›o agree closely with the results of experiment. The real ion between fact and theory, however, will be best seen comparing the two columns of densities. The differences re always less than 0·1.

	II.	III.	IV.	V.
	2·295, Clarke.	11·33	11·00	2·363
l.	1·998, Kremers.	21·27	22·00	1·932
r.	3·102, Clarke.	28·05	27·50	3·164
	3·485, "	38·45	38·50	3·481
'.	2·558, "	16·41	16·50	2·545
l.	2·145, Buignet.	27·27	27·50	2·127
r.	3·079, Kremers.	33·45	33·00	3·121
.	3·450, Filhol.	43·48	44·00	3·409
	2·096, Clarke.	28·20	27·50	2·113
.	1·945, Kopp.	38·35	38·50	1·937
'.	2·672, Playfair, Joule.	44·57	44·00	2·707
	3·056, Filhol.	54·35	55·00	3·020
'.	3·202, Clarke.	33·64	33·00	3·167
l.	2·209, "	54·78	55·00	2·200
r.	2·780, "	59·53	60·50	2·735
.	3·023, "	70·29	71·50	2·972

'e now we have sixteen compounds of a single type, one of which agrees with the rule. In each case the ular volume comes out a multiple of 5·5, or very nearly. ›ne substance in the list seems to be in any way abnormal, y, rubidium fluoride, with its volume of 33. The other les in this group have volumes less by 11 than those of ›rresponding chlorides, but in this case the difference is A curious progressive relation is also worth noting. If we compare the five chlorides given in the table we shall see that upon arranging them in the order of their molecular weights the differences between successive members of the series increase as we ascend. Thus LiCl and NaCl differ by 5·5, NaCl and KCl by 11, KCl and RbCl by 16·5. This regular difference-increase is certainly suggestive of some law yet to be clearly made out.

A similar relation to Kopp's hydrogen volume is also afforded by the two other compounds. Sodium hydride, Na_2H, discovered by Troost and Hautefeuille,* with a density of 0·959, has a molecular volume of 49·1, or very nearly 5·5×9. Still more interesting is iodine monochloride, so carefully studied by Hannay.† At 0° the solid substance has a specific gravity of 3·263, and a molecular volume of 49·8, thus varying only 0·3 from a multiple of 5·5. At 101° the chloride boils, and at 98° its density is 2·958, having a volume of 54·9. Probably an absolutely correct determination at its boiling point would give a value of 55. So we may say that iodine monochloride, both as a solid at 0°, and as a liquid at its boiling point, has molecular volumes multiples of that of hydrogen.

As for the haloid salts of silver, they cannot with certainty be included among the substances connected by this multiple relation. The fluoride agrees fairly, however, having a density of 5·852, Gore, and a molecular volume of 21·7 instead of 22. The chloride and iodide may be forced to agree by selecting out the density determinations of certain investigators, and rejecting other decidedly discordant data. The bromide does not agree at all. A determination of my own for precipitated AgBr gives a density of 6·215, 17°, and a corresponding volume of 30·25. Other determinations are even more discordant than this. Silver salts generally have molecular volumes equal or nearly equal to the corresponding sodium compounds; that of sodium bromide being 33·0. Silver fluoride, it will be seen, diverges also from the sodium salts. For thallium, our data are insufficient. Its monochloride has a molecular volume approximating to a multiple of 5·5, but not closely enough to be satisfactory. The sesquichloride does not even approximate. At some future time I hope to be able to revise and extend our specific gravity determinations for this class of thallium salts.

Now to sum up. Including the silver and thallium salts we know the densities of twenty-five substances containing only univalent elements. Of these, twenty have molecular volumes multiples of that of hydrogen, three are doubtful. two apparently disagree. We may, therefore, safely assert the following general law, subject to possible exceptions. *Every compound*

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* Compt. Rend., vol. lxxviii, 970.

† Jour. Chem. Soc., II, xi, 818.

ntaining only elements of the hydrogen group has a molecular lume an even multiple of that of hydrogen. This is probably at a hint of some more general regularity connecting other ements and other groups.

Postscript.—Since the above pages were written, there has een published by Johnson a density determination for potasum triiodide, KI_3. (Chem. News, xxxiv, 256.) This deterination, 3·498, corresponds to a molecular volume of 120·1. 21 is an exact multiple of 5·5, and gives a theoretical density 3·472. The multiple relation now holds good in twenty ses out of twenty-five.

RT. XXXIV.—*On the identity of the so-called Peganite of Arkansas with the Variscite of Breithaupt and Callainite of Damour;* by ALBERT H. CHESTER.

A NUMBER of years ago I obtained some specimens of a ineral, said to come from Colorado, which, after a hasty exnination, was called peganite. More recently, I have received ecimens of the same mineral from Montgomery County, rkansas, from which locality the first undoubtedly came. nalyses were made of both, with the results given below; o. 1 is of the amorphous mineral, and No. 2 is the average two analyses of the crystalline variety. It was found imposble to separate it from the quartz with which it is associated, d a considerable quantity of the latter substance is unavoidly included in each analysis.

	1	2
Phosphoric acid	13·08	22·36
Alumina	9·59	15·72
Water	7·08	11·89
Insoluble residue	69·69	49·86
Total,	99·44	99·83

Deducting the insoluble residue, and calculating to one hunred per cent, we have the results below in columns 1 and 2, hile 3 gives the average of the two, and 4 the oxygen ratio.

	1	2	3	4
Phosphoric acid	43·96	44·74	44·35	5·05
Alumina	32·24	31·46	31·85	3·00
Water	23·80	23·80	23·80	4·32

In four other analyses the ratio of water to phosphate of umina was found to be 1 to 4·04, 4·26, 4·01, and 4·23. The rmula for the mineral must then be Al_2O_3, $P_2O_5+4H_2O$, aking it distinct from peganite, with which it has been confounded. Its composition, moreover, is identical with that obtained by Petersen for the variscite of Breithaupt, and closely corresponds to that of the callais (callainite) of Damour. Analysis 1, below, is by Petersen (Jahrb. Min., 1871, 357) of variscite from Messbach, in Saxon Voigtland; and analysis 2, one given by Damour (after the deduction of 2·10 p. c. of sand), of callais:

	1	2
Phosphoric acid	44·05	43·31
Alumina	31·25	30·09
Iron sesquioxide[1]	1·21	1·86
Magnesia	0·41	
Lime	0·18	0·70
Water	22·85	24·04
Total,	99·95	100·00

[1] With Cr_2O_3 and FeO.

Both of these analyses agree closely with the formula given, Al_2O_3, $P_2O_5+4H_2O$, which requires: phosphoric acid 44·80, alumina 32·49, water 22·71=100. The mineral from Arkansas with also the callainite of Damour should consequently be included under the name *variscite*, given in 1837 by Breithaupt.

The mineral occurs in crystalline crusts on quartz; also rarely in distinct crystals of very small size. These belong to the orthorhombic system, showing prismatic and basal planes. The crust often presents a semi-globular form with a radiated structure. It also occurs amorphous and disseminated through quartz. The colors observed are deep emerald-green, though all shades of bluish green to almost colorless. Some crystals are dark in the middle, and light at both ends. It is transparent to translucent, infusible, and has a hardness of about 4. Before the blowpipe it becomes opaque, friable, and of a deep purple when hot, lighter purple when cold. In the glass tube yields much water and changes in color as above.

Chemical Laboratory, Hamilton College, Clinton, N. Y., Feb. 12.

ART. XXXV.—*On a fibrous variety of Sepiolite from Utah*; by ALBERT H. CHESTER.

SOME years since I obtained, while visiting a silver mine in Utah, specimens of a fibrous mineral which upon analysis proves to have the composition of sepiolite. It occurs in a seam about two inches in thickness cutting across the rock strata and vein at nearly right angles. The following analyses give the composition of two varieties, one of which is white, and the other bluish-green; 1 is the mean of four analyses of e white variety; 3 is a single analysis of the green kind; and and 4 are the respective oxygen ratios for the two.

	1	2	3	4
Silica	52·97	6·16	50·15	6·08
Alumina	0·86		2·06	
Iron sesquioxide	0·70		1·02	
Manganese sesquioxide	3·14		2·09	
Copper oxide	0·87	2·	6·82	2·
Magnesia	22·50		18·29	
Water	9·90	1·92	9·30	1·88
Moisture	8·80		10·32	

One half the water is driven off at a temperature of 100° C., id very little more is lost even up to 200° C., and a full red at is required to expel the last traces. It is hence probable at the moisture which goes off below 110° does not belong the mineral and should not be regarded in deducing the rmula. The formula obtained is $2MgO, 3SiO_2+2H_2O$, which identical with that of sepiolite, of which it is a new and inter- ting variety. Its blowpipe characters, and its behavior with ids are the same as those of sepiolite. It gelatinizes with ydrochloric acid though not entirely decomposed. The green riety, as shown in the analysis above, contains considerable pper, which is obviously the cause of the color, and which ems to replace the magnesia in the composition of the ineral.

Hamilton College, Feb. 14.

RT. XXXVI.—*On Dr. Peale's Notes on the Age of the Rocky Mountains in Colorado;* by J. J. STEVENSON, Professor of Geology in the University of New York.

I HAVE read Dr. Peale's notes with a good deal of care, but is long discussion of my conclusions contains very little in e way of direct argument, which seems to me to call for a ply. At the same time it is necessary to correct some of Dr. eale's statements, which, no doubt without any such intention his part, certainly tend to give a false impression respecting th my facts and my position.

The first of these is on page 172, where the final sentence in e third paragraph seems to intimate that while Dr. Peale es not regard his data as sufficient to extend his generaliza- ons to the entire Rocky Mountain System, I, on the other and, feel no similar hesitation respecting my data, which were rocured within a smaller area. The opening paragraph of hap. XVII of Wheeler, vol. iii, contains a full statement of my pinion concerning the value of my data.

The second of these is on page 174, in the third paragraph. There the statement is made that the Trias is present in southwestern Colorado and northern New Mexico, and the testimony of Dr. Newberry, Prof. Cope, Mr. Holmes and Dr. Peale is offered to prove the truth of the statement. This effort to show the existence of the Trias there, taken in connection with the fact that no reference is made to my mention of the group in that region, is very apt to leave the impression either that I failed to recognize the group or that I had denied its existence; which would be an error in each case. The occurrence of the Trias in that region is used as a strong proof that Trias occurs in the interior in opposition to my assertion that the group is absent in the interior. With all due respect for Dr. Peale's judgment, I submit that the presence or absence of Trias in New Mexico or southwestern Colorado has nothing to do with the "interior," as those districts are outside of the flexed region, which I called the "interior."

The third of these is on page 176, but begins at the bottom of page 175, where the statement is made that my conclusions in favor of upheaval at the close of the Trias, are based upon unconformability observed at Golden, near Colorado Springs, near Cañon City, and also in Huerfano Park. Dr. Peale at once settles the question here by showing that there is no proof of non-conformability at either Golden or Colorado Springs, so that, as I had made a mistake at each of these localities, there is every reason to believe that the same mistake was made at the other localities. Now I grant him all he says about the conditions at Golden and Colorado Springs; the groups are not in direct contact there, and consequently no proof of non-conformability can be found. But that does not concern this matter in any way. As I made no reference to either Golden or Colorado Springs in this connection, I, of course, made no mistake respecting them, so that Dr. Peale's intimation with regard to the localities to which I did refer, is wholly gratuitous.

The fourth of these statements is in the paragraph beginning at the bottom of page 179, and continuing almost to the bottom of page 180. The reasoning in this paragraph may be ingenious, but one would find difficulty, even by the use of the utmost courtesy, in calling it ingenuous. For the sake of avoiding confusion, as well as for the sake of courtesy, it would have been "best to state" in the text that "Prof. Stevenson regards as Cretaceous" the debatable lignite group which Dr. Peale regards as Lower Tertiary. Buried, as this statement is, in the foot notes, it is easily overlooked, and the remark on the following page "that there was no marked action until the close of the Lignitic," in connection with the context, readily appears to contradict the quotation from my report on page 179. But there is no difference between Dr. Peale and myself. When I wrote that chapter in 1874 I regarded the whole Lignitic group as forming the closing portion of the Cretaceous. So I considered the period of accelerated upheaval as occurring at the close of the Cretaceous, that is, at the close of the Lignitic group. Dr. Peale places the action at the same time.

I have no additional facts to offer in support of the provisional conclusions which I offered in the report to Lieut. Wheeler. All the material in my possession is given in that report, and the synopsis of that, which seemed to have a bearing on the age of the system, is to be found in Wheeler, vol. iii, Chap. XVII. Nor am I likely to secure any additional facts either *pro* or *con*, as there is no probability that I shall have an opportunity to revisit the Rocky Mountains for a number of years.

New York, March 9th, 1877.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Velocity of Chemical Reactions.*—**Boguski** and **Kajander** have continued the experiments commenced by the former to ascertain the velocity of chemical reactions. Boguski defines velocity of reaction by supposing that $u=f(a_1, a_2, a_3, \ldots\ldots a_n, t)$, in which u is the quantity of the new body produced in the time t, and $a_1, a_2, a_3 \ldots\ldots a_n$ the conditions under which the reaction takes place. Hence the first differential coefficient, $\frac{du}{dt} f=(a_1, a_2, a_3 \ldots a_n, t)$ represents the reaction-velocity under the conditions given. It remains to find the form of the functions u and $\frac{du}{dt}$. Since all the conditions must be exactly measurable and expressible in numbers, the author chose for experiment the action of liquids on solids, in which the only variables—the temperature being constant—are the surface of the solid acted on and the concentration of the solution. "Concentration" is used to express the value given by the formula $D.\frac{1}{M}.\frac{p}{100}$, in which D is the sp. gr. of the solution, p the percentage content of the body dissolved and M its molecular weight. Since the number of molecules of this body in a unit of volume of the solution is directly proportional to this value, if V represent the volume in c.c., the formula $V.D.\frac{1}{M}.\frac{p}{100}=y$ represents the concentration

used in the experiment. Two modes of stating the results are proposed: 1st, that the quantity of the new body formed in an infinitely short time is proportional to the concentration y at that time; or 2d, that this quantity is proportional to the number of molecules of the liquid which act upon a unit of surface of the solid. Taking the reaction between zinc and sulphuric acid, and assuming that a unit of zinc surface dips in a unit of volume of the acid, the first hypothesis is expressed by the differential equation $d[H_2]=kydt$, in which $d[H_2]$ expresses the quantity of hydrogen set free in the infinitely small time dt, and k is the proportional coefficient. Since 49 parts of H_2SO_4 are required to evolve 1 part of H, we have $[H_2]=-\frac{1}{49}[H_2SO_4]=-\frac{1}{49}y$. Differentiating, $d[H_2]=-\frac{1}{49}dy$. Equating with this the above expression for $d[H_2]$, we have $\frac{dy}{y}=-49kdt$. By integration between the limits y_t and y_0, the value of y_t can be obtained; and by substituting this value for y in the first equation given above, changing the signs and integrating between corresponding limits, $\int_0^{[H_2]} d[H_2]=ky_0\int_0^t e^{-\frac{1}{49}kt}.dt$, there is obtained $[H_2]=\frac{1}{49}y_0 (1-e^{-\frac{1}{49}kt})=\frac{1}{49}(y_0-y_t)$, from which $k=\frac{1}{t}.\frac{1}{49}.\frac{1}{M}$ comm. log. $\frac{y_0}{y_t}$. The experimental results with zinc and sulphuric acid not being uniform, the author took Carrara marble and hydrochloric acid, the marble parallelopipeds being accurately measured. From this the surface-area was calculated and also the volume of liquid required to give a unit of volume to each unit of marble surface. The concentration of the acid was determined volumetrically, giving y_0. The carefully weighed marble was placed in the acid for a known time, then removed, washed, dried and weighed; from the loss, the carbonic dioxide evolved and the acid consumed were determined, giving y_t. From these data, by the formula $t=\frac{73}{44}kM \log \frac{y_t}{y_0}$, the value of $\frac{73}{44}kM$, and consequently of k, was calculated. As a mean of 53 well agreeing experiments, the value of $\frac{73}{44}kM$ was found to be 0·01765, and of k 0·0444±0·003 at 20° and 760 mm. Since this value is constant, it follows that the first supposition represents a fact, and that the quantity of carbon dioxide gas evolved from marble in a definite moment of time is directly proportional to the concentration of the acid at that moment. In connection with Kajander, Boguski has now extended the investigation to other acids, using nitric and hydrobromic in the new experiments. They find the values $\frac{126}{44}kM$ and $\frac{162}{44}kM$ respectively 0·0175, and 0·0185, being sensibly the same as that above given; hence the coefficient k, for these three acids is inversely proportional to their molecular weights. From the equation $d[CO_2]=kydt$, we have the velocity of the reaction $v=\frac{d[CO_2]}{dt}=ky$. Consequently when different acids of the same concentration act upon marble, the velocity of evolution of carbon dioxide is inversely proportional to their molecular weights.—*Ber. Berl. Chem. Ges.*, ix, 1646, x, 34, Jan. 1877. G. F. B.

2. *On the Equivalence of Nitrogen.*—LADENBURG and STRUVE have sought to throw some light upon the equivalence of nitrogen by studying carefully and comparing directly the properties of triethylbenzylammonium chloride and iodide on the one hand, and those of benzyltriethylammonium chloride and iodide on the other. The former bodies were prepared directly by acting on triethylamine with benzyl chloride in a sealed tube at 100°. A white crystalline mass results, which is soluble in water, and is easily crystallized therefrom. The platinum double chloride crystallizes easily from hot water, and has the formula $(N(C_2H_5)_3 C_7H_7Cl)_2PtCl_4$. The iodide, obtained by the action of silver oxide and hydriodic acid on the chloride, when its solution is evaporated on the water-bath, is very readily decomposed, yielding irritating odors of benzyl iodide. The second bodies were obtained by acting on benzylamine with ethyl iodide at 130°. The platinum double chloride gave the formula $(NC_7H_7(C_2H_5)_3 Cl)_2PtCl_4$. When, however, aqueous solutions of benzyltriethylammonium iodide are evaporated on the water-bath no benzyl iodide is formed even when the evaporation is carried to dryness. This difference in the behavior of the two bodies leads the authors to regard them as isomeric and not identical. The same conclusion is drawn from the form of crystallization of the platinochlorides, one being apparently monoclinic, the other orthorhombic. From this it follows that the five bonds of nitrogen in ammonium chloride have not all the same value.—*Ber. Berl. Chem. Ges.*, x, 43, Jan. 1877. G. F. B

3. *Action of fuming Nitric acid on Coal Gas.*—AKESTORIDES has studied the products obtained from coal gas by passing it through fuming nitric acid, until a brown layer separated and crystals began to appear. The heavy layer evolved on heating torrents of nitrogen tetroxide gas, and on adding water, a yellow nitro compound separated which was not examined. The crystals consisted of oxalic acid. The lighter fluid, which had the odor of nitrobenzene, consisted essentially of two nitro-compounds, one boiling at 205°, the other at 222°, being nitrobenzene and nitrotoluene. A small quantity of a third body, boiling about 300°, was obtained, probably a nitro-naphthalene. In examining for the source of the production of oxalic acid, the author found that benzene gave none when treated with fuming nitric acid, while toluene and xylene gave small quantities, and ethylene afforded it abundantly. Hence the author concludes, contrary to Berthelot's opinion, that ethylene is absorbed by nitric acid and is oxidized to oxalic acid; this substance being permanent even in fuming acid.—*J. pr. Ch.*, II, xv, 62, Jan. 1877. G. F. B.

4. *On oxidized Platinic sulphide.*—E. v. MEYER has examined the so-called oxidized platinic sulphide, long known for its special catalytic activity. It was prepared by precipitating a hot solu-

tion of potassium platino-chloride by hydrogen sulphide, washing the precipitate by decantation with hot water, and drying for several days on the water-bath, during which latter process the oxidation takes place. It appears as a heavy black powder, which on continuous heating at or above 100° suffers further oxidation. If the heating be rapid, oxygen is absorbed, sulphurous and sulphuric oxides are formed, and platinum is left. On examination it was found to contain the elements of water; and upon analysis two products were distinguished, one the normal hydrate $PtS\left\{\begin{matrix}OH\\OH\end{matrix}\right.$, the other derived from two molecules of this by the loss of water, $\left.\begin{matrix}PtS\\PtS\end{matrix}\right\}O\begin{matrix}OH\\OH\end{matrix}$. The analytical results for the latter were satisfactory; but the former could not be obtained as pure. The sulph-oxide (PtS)O does not appear to exist free. The author finds the body to be an energetic oxidizer, H_2S yielding S, SO_2 giving SO_3, HCl evolving Cl, NH_3 producing HNO_2 and HNO_3, oxalic acid giving CO_2, ferrous being oxidized to ferric salts, alcohol to aldehyde and toluene yielding benzaldehyde.—*J. pr. Ch.*, II, xv, 1, Jan. 1877. G. F. B.

5. *Preparation of Glycollic acid by reduction of Oxalic acid.* —CROMMYDIS has succeeded in producing glycollic acid from oxalic, by the action upon it of nascent hydrogen. The oxalic acid dissolved in water, was mixed with zinc turnings and heated for eight days in a water-bath. The liquid was then filtered, treated with milk of lime, again filtered, the excess of lime removed by oxalic acid, boiled to destroy the glyoxylate, again filtered, and evaporated to crystallization. On cooling, crystalline warty masses formed which were soft like wax, and which on analysis proved to be calcium glycollate, crystallized with four molecules of water. The copper and zinc salts were also prepared and examined.—*Bull. Soc. Ch.*, II, xxvii, 3, Jan. 1877. G. F. B.

6. *On the Decomposition of the Oil of Turpentine at high Temperatures.*—SCHULTZ has studied the products of the action of high temperatures upon oil of turpentine, using iron tubes and heating them in a Hofmann furnace to a dull red heat. The oil distilled between 158° and 161°, and was caused to flow into the heated tube drop by drop. Carbon was deposited, combustible gases were evolved which were not examined, and a black tar collected in the well-cooled receiver connected with the apparatus. This tar was fractionated, and the fractions examined. The portion boiling below 200° afforded benzene, toluene and xylene; that below 300°, naphthalene; and that above 300°, phenanthrene, anthracene and methyl-anthracene.—*Ber. Berl. Chem. Ges.*, x, 113, Feb. 1877. G. F. B.

7. *Constituents of Beech-wood Tar-creosote.*—TIEMANN and MENDELSOHN have examined the properties of creosol and phlorol, constituents of that fraction of beech-tar creosote boiling near 220°. By the action of acetic oxide on potassium-creosol, acetyl-creosol is obtained, and this by oxidation and removal of the

acetyl, gives vanillic acid. Creosol is therefore parahydroxylmetamethoxyl-toluene. From phlorol, methyl-phlorol and oxyphthalic acid were prepared.—*Ber. Berl. Chem. Ges.*, x, 57, Jan. 1877. G. F. B.

8. *Measurement of High Pressures.*—M. L. CAILLETET has recently constructed a manometer capable of measuring high pressures, on the slope of a hill near his laboratory at Chatillon-sur-Seine. The apparatus consists of a metallic tube 70 meters long and about 2 mms. interior diameter. One of the extremities of this tube is soldered to a reservoir of iron filled with mercury and placed at the base of the hill. To the free extremity of the tube a large glass tube is attached, which forms the upper end. When the mercury contained in the reservoir is compressed, it is forced up into the metallic tube so as partly to fill the glass tube, which is fixed on a vertical plate. This portion of the apparatus is movable, owing to the flexibility of the metallic tube and may be carried to one side and placed against either of several stakes arranged along the slope and having indices distant from each other exactly 760 mms. vertically. Fractions of an atmosphere are measured by a graduated scale resting against the stake. Attached thermometers give the correction for temperature. A pressure of thirty-four atmospheres may thus be obtained. M. Cailletet proposes shortly to measure the compressibility of gases at very high pressures by the aid of the shaft of a deep mine. For this purpose it is only necessary to lower into the shaft to a known depth a cylindrical reservoir of iron about two meters long and containing the apparatus with gilt glass he previously used n testing the law of Mariotte. A small metal tube starting at the surface is attached to the iron reservoir. When mercury is turned into the extremity of the metallic tube, it descends into the reservoir and produces a pressure which is transmitted to the gas n the interior. This pressure is accurately measured by the difference of level of the mercury in the two tubes. Thus with no special apparatus and simply by the aid of mercury we can compress a gas several hundred atmospheres and at the same time measure exactly the pressure produced.—*Comptes Rendus*, lxxxiv, 83. E. C. P.

9. *Diathermaneity of Metals and Paper.*—M. AYMONNET, from his own observations, together with those of Wiedemann and Franz, on the rapidity with which the equilibrium of temperature s established in bars whose coefficients of conductibility are ought, arrives at the following conclusions:

1st. That metals and paper are not athermanous as is generally upposed.

2d. That they are more diathermanous for the obscure rays emanating from metallic bodies brought to a temperature below 00° than for the luminous heat rays, or those near the red end of he spectrum.

3d. That they have absorbent powers less than that of water. The complement of the inverse ratio which exists between the quantity of heat which penetrates normally into a body and that which goes out of it in the same direction is here called the absorbent power.

4th. That it is possible to find a mathematical relation between the absorbent power of a body and its coefficient of conductibility. *Comptes Rendus*, lxxxiv, 259. E. C. P.

10. *Increase of Weight by Combustion.*—M. V. **Meyer** suggests a form of lecture-room experiment to show the increase of weight in the combustion of a substance at the expense of the oxygen of the air. Some years ago Professor Hoffmann showed a practical method of demonstrating experimentally the increase of weight of iron when burned in oxygen, but there has been as yet no simple means of proving this fact for objects like a candle, which appear to the eye to diminish. A candle is attached to each pan of a balance, and above one a glass tube open at both ends is hung, at nearly the height of the wick. In this tube is a piece of wire gauze holding some pieces of caustic soda; after balancing the candles, one of the candles is lit, when the products of combustion are retained by the soda and this end of the beam descends. At the end of a quarter of an hour the difference in weight may amount to three grams.—*Ber. Chem. Gesell.*, ix, 1866; *Bib. Univ.*, ccxxix, 106. E. C. P.

11. *Absorption of Light.*—M. **Lippich** of the Vienna Academy has recently been investigating the influence of the mean distance of absorbent particles upon absorption. As such an influence must be especially prominent when the substances afford well-defined absorption bands, and, with considerable density, show no strong colors, he chose for his experiments the nitrate of didymium oxide, which has these properties in a high degree. A pretty concentrated aqueous solution of this salt in a vessel one centimeter thick was spectroscopically compared with a solution having a concentration of only 0·1, 0·05 of the first. These solutions were in tubes of ten and twenty centimeters severally. A Steinhiel spectroscope was used. and the light sources were two gas lamps so regulated that both spectra showed the same brightness on the parts that were free from absorption. Even with the concentration ratio 1·10, there were marked differences in the absorption bands. The very characteristic bands in the yellow and yellow-green were, for the more concentrated solution, considerably broadened toward the red end of the spectrum, while the sharp limit toward the violet was the same for both solutions. The much narrower bands in the green showed quite a similar behavior. In the other parts differences were observed with difficulty. Besides this difference in the breadth of the absorption bands, there were others in the distribution of the bright parts.—*Nature*, xv, 208. E. C. P.

12. *Lippmann's Electrometer.*—Professor **Dewar** exhibited to the Physical Society a simple electrometer which he has designed, founded on the discovery of Lippmann that the capillary constant is not really independent of the temperature or condition of the

urface, but is a function of the electromotive force. If a capillary ube be immersed in mercury, and dilute sulphuric acid be placed n the tube above the mercury, and a current from a Daniell's cell e so passed through the liquids that the mercury forms the nega-ive pole, the column will be depressed to an extent dependent on he diameter of the tube. In making an electrometer, Professor Dewar has increased the sensitiveness by connecting two vessels f mercury by means of a horizontal glass tube filled with the etal, except that it contains a bubble of dilute acid. The tube ust have an internal diameter of two millimeters, and it is essen-ial that it be perfectly clean, uniform in diameter and horizontal. The instruments exhibited were constructed by Messrs. Tisley and Spiller, and Professor Dewar showed that it is possible by means f them to measure an electromotive force equal to $\frac{1}{10000}$ of a Daniell's cell; forces capable of decomposing water must be easured by causing two currents to act against each other. The index bubble is brought to zero by uniting the mercury cups y a wire. The apparatus is very convenient, as it requires no reparation and is extremely simple in its action. He next showed n instrument arranged by Mr. Tisley for producing a current by he dropping of mercury from a small orifice into dilute sulphuric cid; if the vessels containing the mercury and the acid be con-ected by a wire a current is found to traverse it. He then ex-ibited a manometer suitable for measuring very slight variations f pressure, and he illustrated the use of it for proving Laplace's aw that the internal pressure multiplied by the diameter of a soap ubble is constant. It consists of a U-tube one arm of which is bout fifteen inches long and is bent horizontally and levelled with reat care. If the shorter arm be connected with a tube on which bubble has been blown and the diameter of the bubble be varied, he position of the extremity of the alcohol column will be found vary in accordance with the above law.—*Nature*, xv, 210.

E. C. P.

13. *Entwickelung der theoretischen Ansichten über die gepaarten chwefelverbindungen;* von Geo. A. Smyth (of Amherst Mass.). 22 pp. 8vo. Berlin, 1876.—In the above titled Monograph the uthor has endeavored to give a critical, historical sketch of the heoretical views concerning the large and important family of rganic-inorganic bodies, which may be appropriately designated s the *conjugated* or *copulated* compounds of sulphur, and which omprises the classes of *sulpho- sulphi-* and *hyposulphi-* acids, the *lphohydrates* or *mercaptanes*, and their derivatives. Beginning ith the discovery of the first organic derivatives of H_2SO_4 hrough the experiments of Dabit, Sertürner, Vogel, Gay-Lussac, ennell and Faraday, and the formation of the first sulpho-com-ounds by Faraday and others, in the early part of this century, discusses in successive chapters the older modes of viewing hese bodies by Faraday, Magnus, Liebig, Regnault, Berzelius, litscherlich, and Fehling, the views of the originators of the heory of substitution, those of the followers of the electro-chemical

radical theory up to the time of Kolbe's modification of this theory, and the hypothesis of copulation, the further development by disciples of the radical theory in accordance with the *atomistic* conception of combination, the typical theory and the copulated compounds, the development of atomistic views of combination by the typicists, and the present modes of interpreting the copulated compounds. At the close a chapter is added describing briefly the discovery and the character of the different classes of the conjugated sulphur compounds, and more especially those of the sulpho-acids, their formation out of different groups of organic bodies, the number of sulpho-substitutions, their modes of formation, their metamorphoses through modifications of the inorganic group, and their decompositions by separation of the organic from the inorganic compound parts. In connection with this chapter some points of theoretic interest, such as the constitution of sulphurous acid, Kolbe's prognosis of sulpho-alcohols and aldehydes, etc., which could not be conveniently discussed in the main body of the work, are taken up.

After discussing the older modes of interpreting the sulpho-compounds, which were, from the insufficient data, necessarily crude, and which failed to give any systematic explanation of the action of H_2SO_4 upon organic bodies, the compounds being variously regarded as combinations of organic bases with sulphuric, hypo-sulphuric acid, etc., and after briefly sketching the rise of the theory of copulation, which was largely owing to the study of sulpho-acids, the author next treats of the development of the atomistic conception of combination by Kolbe and Frankland in the sixth decade, maintaining that we find here the first satisfactory explanation of the constitution of the copulated sulphur compounds, and the first conception of the sexivalence and consequently variable atomicity of sulphur. The reasons for Kolbe's explanation of the constitution of these bodies, as compounds of sexivalent sulphur having exerted so little influence, and of his claims to having established the hexavalence of sulphur, and also the quadrivalence of carbon having been so generally overlooked are sought for principally in his retention of equivalent formulæ, which could not express his own views of chemical combination, and which showed that his conception of atomicity, though broadly stated, was not defined with sufficient sharpness and definiteness.

Under the head of the typical theory in its relations to the copulated sulphur compounds, which is the subject next treated, the attention of the reader is directed to the influence of Gerhardt's discoveries of the sulpho-chlorides and amides, and Buckton's and Hofmann's preparation of numerous disulpho-acids, Gerhardt's comparison of the sulpho-compounds with the carbonic acid series as compounds containing the radicals SO_2 and CO respectively, Limpricht's and von Uslar's investigations of the sulpho-benzoic acid compounds, their view of the substitution of H in the organic radical by SO_2, Mendius' view of the typical formulæ as an expression of the constitution of chemical compounds, Kekulé's mixed types, and the controversy between the champions of the typical theory, being the subjects most prominently taken up. The typical theory contributed, according to the view of the author, very little toward the advancement of our theoretic knowledge of the copulated sulphur compounds. It failed signally to throw light upon the peculiar nature of the sulpho-acids, it proved itself to be utterly unable, as the interpretations of Carius's investigations abundantly show, to explain any difference of constitution between the sulpho-acids and the metameric hypothetical primary ethers of sulphurous acid, while the adoption of complex multiple and mixed types showed the fruitlessness of all attempts to refer compounds capable of undergoing manifold reactions to any typical bodies. But an atomistic explanation of the copulated sulphur compounds presented peculiar difficulties to the disciples of the typical school, as it necessitated the acceptance of a higher atomicity of the sulphur-atom, and accordingly it was not until the discovery of the true primary ethers of sulphurous acid, and of the isomeric phenole sulpho-acids, and furthermore of the difference in constitution of these acids from the primary acid ethers, that the typicists adopted an atomistic conception of combination.

After sketching the gradual development of atomistic and structural views by the former typicists, as shown most prominently in the attempts of Kekule to derive the copulated sulphur compounds from a dyad S, and in the adoption by Butlerow and Erlenmeyer of a higher atomicity for S, the author goes on to compare the views held at present with those advanced by Kolbe, endeavoring to show that the explanations of the chemical deportment of the sulpho-compounds now given are essentially the same as those given by Kolbe, some twenty years ago, that these chemists differ however from Kolbe in their general conception of the constitution of a body, and in their views as to the manner in which the S-atom is combined with the organic radical. The latter difference of opinion is, according to the author, the only essential one, and he, although assenting to Kolbe's general views as to the chemical constitution of a body, does not hesitate to accept Butlerow's definition of the sulpho-compounds, i. e. as compounds of a sexivalent S, in which the S is combined directly with a C-atom of the organic body.

II. GEOLOGY AND MINERALOGY.

1. *Note on the Age of the Crystalline Rocks of Wisconsin;* by **ROLAND IRVING**. (Communicated.)—In a note on the "Huronian of Canada," published in this journal for December last, Mr. A. R. C. Selwyn, criticising Mr. F. H. Bradley's reference of the Canada, Wisconsin, and Michigan Huronian to the Lower Silurian, uses the words: "If, however, it is an established fact that in Minnesota (Michigan?) and Wisconsin the same Huronian rocks are unconformably covered by the Potsdam sandstone . . . ." Such

an unconformability in Wisconsin is certainly a fact, established not by one or two instances, but by many. The exact junction between the two formations is often to be seen, the almost loose sand of the Potsdam, with numerous fossils, as also fragments derived from the older rocks, lying upon and wedged in between the tilted ledges of Huronian quartzite, schist, or other rock. Exactly similar unconformability is to be seen at the Dalles of the St. Croix River between the Potsdam and Copper series; the horizontal beds of the former, filled with shells of *Lingulella*, lying directly upon the columnar melaphyre (?) of the latter series, the exact junction of the two series being exposed. The crystalline rocks of Wisconsin include unquestionably two distinct terranes, the one lying unconformably upon the other, as is beautifully shown at Penokee Gap, on Bad river, in the Lake Superior country. Here a white siliceous marble of the Huronian, overlaid by hundreds of feet of distinctly bedded slaty rocks, and dipping northward, is to be seen within twenty feet of large ledges of dark colored amphibolic gneiss, whose bedding planes dip southward and strike in a direction diagonally across that of the more northern beds. There are no doubt instances where the two series are difficult to separate, similar rocks occuring in both groups, but the existence of the two is incontestable, and their unconformability with the unaltered Potsdam equally so. The facts *proven* thus far with regard to the older rock series of Wisconsin may be briefly summarized as follows: the oldest (I) are gneisses and granites with other rocks; these are overlaid unconformably by (II) a series of quartzites, schists, diorites, etc., with some gneiss and granite; these in turn are overlaid—probably also unconformably, but this is not certainly proven—by (III) the Copper series, which includes greenstones and melaphyres, and also great thicknesses of interstratified sandstone, melaphyres, amygdaloids and shales, the whole having a thickness of several miles; these finally are unconformably covered by (IV) a series of unaltered horizontal sandstones including numerous fossils, many of which are closely allied to those of the Potsdam sandstone of New York, and all of which have a marked Primordial aspect. I and II are referred to the Laurentian and Huronian systems of Canada, because they bear the same relations to one another and to the Copper series that these systems do. However this may be, it will be seen that in order to include the Wisconsin crystalline rocks within the Silurian, Mr. Bradley would have to stretch that term so as to cover three entirely distinct terranes, each overlying its predecessor unconformably and many thousand feet in thickness, the highest of the three in its turn overlaid unconformably by horizontal sandstone with Primordial fossils. As to any of the Wisconsin or Michigan crystalline rocks being altered equivalents of the Primordial and newer strata of the eastern States, such an hypothesis is certainly untenable for a moment. Such things may and in all probability do occur in the Appalachians, but there ertainly has been no period of metamorphism in the region of the orthwestern States since the beginning of the Primordial.

University of Wisconsin, March 8th, 1877.

2. *Microscopical Petrography;* by Ferdinand Zirkel. Being olume VI of the series of Reports of the U. S. Geological Exploation of the 40th Parallel, Clarence King, Geologist-in-charge. ubmitted to the Chief of Engineers, and published by order of he Secretary of War under authority of Congress. 298 pp. 4to, ith twelve plates. Washington, 1876.—The great region west f the Front Range of the Rocky Mountains, including the part in he vicinity of the 40th Parallel, abounds in igneous rocks, from olerytes to trachytes and related kinds, some of them closely like ocks of central and southeastern Europe; and Mr. King has done ell in looking to Europe for the study and description of his pecimens, and has been most fortunate in securing the labors of rof. Zirkel, the leading author in microscopic lithology. The esults are therefore excellent, and at the same time they give to he American student the present European use of the names of ocks.

The Report commences with an Introduction reviewing the inds of crystalline rocks and their microscopic distinctions. In his chapter Prof. Zirkel states that in his descriptions he uses the erm "ground-mass" for the mass of a rock where it is distinctly rystalline granular under the microscope, and "base" when there s an amorphous paste not crystalline granular under the highest agnifying power, though containing, except in many obsidians, rystalline minerals.

He remarks also on the evidence that the crystalline minerals n the "base" were formed while the latter still had a flowing ovement, as shown by the minerals ranging in straight or wavy nes, and by their fractures and abrupt bends or displacements; ence the positions and forms of the crystals have been partly etermined by the flowing; and hence, also, the rock has not ndergone any metamorphic changes since solidification took lace. Those rocks whose micro-fluidal structure is particularly istinct are generally proportionally rich in broken crystals shivred into detached sharply angular fragments.

The feldspar-bearing igneous rocks he divides as follows:

I. The FELDSPAR ORTHOCLASE.—(*a.*) *Containing quartz or an xcess of silica:* granite, granite-porphyry, felsite-porphyry, rhylyte, obsidian, pearlyte, pumice, pitchstone.—(*b.*) *Containing no uartz, and often with more or less plagioclase feldspar:* syenyte, ugite-syenyte, quartzless orthoclase-porphyry, trachyte, augiterachyte.—(*c.*) *Containing no quartz, and with more or less nephelte or leucite:* Foyayte, miascyte, orthoclase-porphyry, phonolyte containing nephelite), and leucite and sanidin rocks.

II. The FELDSPAR OF THE PLAGIOCLASE OR TRICLINIC SERIES.—a.) *Containing hornblende:* quartz-dioryte, dioryte, porphyryte, ornblende-porphyry, propylyte, quartz-propylyte, hornblendendesyte, and dacyte.—(*b.*) *Containing biotite:* mica-dioryte.—(*c.*)

Containing augite: diabase, augite-porphyry, melaphyre, augite-andesyte, feldspar-basalt (including doleryte and anamesyte), and tachylyte.—(*d.*) *Containing diallage:* gabbro.—(*e.*) *Containing hypersthene:* hypersthenyte.—(*f.*) *Containing olivine:* (serpentine) "forellenstein."

III. Containing NEPHELITE as the feldspar mineral.—Nephelinyte and nepheline-basalt.

IV. Containing LEUCITE as the feldspar mineral.—Sanidin-leucite rocks and leucite-basalt.*

To understand this list it is necessary to have in mind some points in German usage connected with the naming of rocks. First, as to the affix, *porphyry.* It is not, as might be inferred, the name of a natural group or family of rocks, but, as the list shows, it is applied to rocks of various groups. It signifies really a *porphyritic variety* of some kind of rock. Felsite-porphyry is a porphyritic felsite (typical porphyry); granite-porphyry is a porphyritic granite, though restricted by Zirkel to a kind in which the granite is of very fine grain, between ordinary granite and felsite. So in cases, not above particularized, diabase-porphyry is a porphyritic diabase, dioryte-porphyry, a porphyritic dioryte, and so on. Again, the affix is used where the disseminated crystals are not feldspar, but some other mineral: thus, hornblende-porphyry, as used by Zirkel, is a gray hornblendic rock in which the large disseminated crystals are hornblende; and augite-porphyry, one in which the crystals are augite. The science would be better off without the word, except as used in the adjective form.

Further: syenite of the Germans is a rock consisting of hornblende and orthoclase *without* quartz, unlike the rock of Syene, Egypt, which originated the name. Syenite containing quartz as a prominent constituent is made a variety of granite—although having its nearest relations to other hornblendic rocks; and, if not made the typical syenite, entitled, by usage elsewhere in the above list, to the name *quartz-syenite.*

Again, the names of some kinds of rocks are made to depend on their geological age—an igneous rock if of Tertiary age having one name, and if older than Tertiary, another. Thus, labradorite and augite along with more or less magnetite make together a rock which is called *basalt* or *doleryte* if Tertiary or younger, and *diabase* if of earlier date. It is a method of naming which might multiply names indefinitely, and which has nothing to commend it. It is to be noted also that Zirkel uses the name basalt in place of doleryte. Both basalt and diabase are described as often containing *viridite* or a hydrous chloritic mineral. The term melaphyre is restricted to an amygdaloidal basalt—an application not always easily made, since the same dike or mass of rock is often amygdaloidal in one small part and not through the rest of the mass, and there is an indefinite gradation between such melaphyre and the chloritic basalt. Peridotyte, or basalt containing olivine, is left as a variety of basalt.

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* The *y*, in the last syllable of the names of many of the rocks, is inserted by the writer.

Of the above mentioned rocks, those found in western America nclude, under I, granite and granite-porphyry, felsite-porphyry, syenite; under II, dioryte, hornblende-porphyry, propylyte, quartz-propylyte, hornblende-andesyte, dacyte, trachyte, rhyolyte, diapase, melaphyre, gabbro, augite-andesyte, basalt; under IV, leucite rock.

The volume is chiefly devoted to the description of these rocks from different localities, after a study of microscopic sections, and comparisons with similar rocks of other countries; and numerous very singular and interesting facts are brought out, besides important illustrations of the relations and mode of origin of the rocks. We add some notes respecting them, following the order in this list.

Propylyte is the most prominent rock of the Washoe district, Nevada, constituting the entire Virginia range. It is a grayish-green rock, consisting mostly of a plagioclase or triclinic feldspar, n small crystals or grains, and hornblende, the latter disseminated n minute points or crystals through the former, and often in part changed to chlorite or epidote. Apatite is sometimes present, and occasionally biotite. In mineral constitution it is scarcely distinct from dioryte, the silica, according to the analyses given, amounting o 64 to 66 per cent. It is of Tertiary age, and hence it is not called dioryte; but, in addition, it has generally more of the aspect of a modern igneous rock. A quartziferous variety is the *quartz-propylyte.*

Andesyte has, according to Zirkel, the constitution essentially of propylyte, that is, it consists mainly of a plagioclase feldspar and hornblende; and the physical differences drawn out on page 133—uch as a purer gray color, the hornblende in coarser crystallizaions, etc.—are feeble in kind and degree. The analyses, however, give it about 60 or 61 per cent of silica, and this would make the feldspar of the rock to contain four to five per cent less of silica. Andesyte, moreover, has sometimes a pasty or semi-glassy groundnass. It occurs with the propylyte at various localities.

Dacyte is a *quartz-andesyte*, and this variety also occurs at Washoe and elsewhere. The color varies from light gray to dark blackish-brown. The ground-mass is often rhyolitic and ometimes spherulitic, and thus differs from that of andesyte and propylyte. The analyses show that the feldspar contains relatively ittle lime, and therefore must be, in the main, andesyte or oligoclase. The quartz, unlike that of quartz-propylyte, shows no fluid-nclusions when microscopically examined.

Trachyte is described as occurring in the vicinity of Washoe, and between there and Pyramid Lake. The rock consists of sandin or glassy orthoclase, but part of it—the older—contains a plagioclase feldspar also, and thus graduates toward andesyte. Tridymite was observed in the younger trachyte in thin 6-sided plates grouped together in great numbers. A "half-glassy-looking rock" from the Cow Hills, between Sheep Corral Cañon and Wadsworth, of dark brownish-black color, containing sanidin, and also pale green augite with some plagioclase feldspar and hornblende, is called an *augite-trachyte.* It resembles in general composition the augite-syenyte of vom Rath, which constitutes the larger part of Mt. Monzoni in the South Tyrol. Other localities are mentioned of trachyte and of this augite-trachyte.

Rhyolyte was so named by Richthofen in 1860. It was made to include certain trachyte-like or felsitic and more or less glassy rocks which contained disseminated quartz, and bore "clearer evidence than other rocks of having once flowed in a viscous state." The more or less glassy kinds comprise obsidian, pearlstone, and pumice. These Zirkel designates *glassy rhyolyte.* Other kinds, felsitic and sometimes porphyritic, not appearing glassy, but showing a fluidal structure in having the ingredients arranged in parallel wavy bands, instead of even-grained, as seen in microscopic sections, he designates *proper rhyolyte;* and certain granite-like kinds (not observed among the rocks of the 40th parallel) he calls *nevadyte.* Rhyolyte is found at several places in Nevada, and many varieties are particularly described and figured. They sometimes contain disseminated quartz crystals. or grains as large as peas. In some the structure is fine granular throughout; in others, there are glassy lines or patches; in others, spherulites; and some are glassy throughout.

Augite-andesyte contains over 58 per cent of silica—in this differing from most igneous augitic or pyroxene rocks. A variety from west of Basalt Creek, Washoe, is brownish-black, somewhat resinous in luster, with "white feldspar crystals which are seldom tabular," and contains hyalite in its amygdaloidal cavities and fissures. The base is partly glassy. The feldspar is partly orthoclase (sanidin) in twins, and partly a triclinic species, the latter predominating. The percentage of silica was found to be 58·015. The same rock has been observed on Teneriffe, Java, Chimborazo, in Hungary, etc. Augite-andesyte is near the melaphyre of some lithologists, but differs in the base being partly glassy. It shows its relation to basalt by containing some chrysolite. The rock also occurs red, blackish, and of other colors.

Basalt is described from various localities. In a variety from Kawsoh Mountains, having a structure "intermediate between the micro-porphyritic and the even-grained," microscopic aggregations of tridymite crystals were observed, in the form of thin hexagonal plates, partly overlapping like tiles and partly in groups. This is the first time tridymite has been met with in basalt; and it is remarked that "since the basalt comes to the surface through or near strata of infusorial silica, it is not impossible, as Mr. Clarence King has suggested, that an included fragment of this silica may be the source of the tridymite, in which case it would of course be a substance originally foreign to basalt."

Leucite rocks are described from the Leucite Hills, northwest of Point of Rocks, Wyoming Territory. They are light yellowish-gray felsite-like rocks, very rich in leucite crystals, and containing augite in grains yet sparingly, with no feldspar of any kind. They thus differ widely from the European leucite rocks.

We here leave the volume. It is a rich treasury of facts respectig American and other igneous rocks, and merits thorough study i every part by those who would fully understand their nature nd relation. J. D. D.

3. *Note upon the Connecticut Valley Helderberg;* by C. H. Itchcock. (Communicated.)—At the close of an article upon Ielderberg rocks in New Hampshire (this Journ., III, vol. vii, p. 71), I proposed to discuss later the relations of the Bernardston, Iass., Helderberg limestone to the associated rocks in Hinsdale, I. H., and Vernon, Vt. This has been done fully in the second olume of the Geology of New Hampshire, which will be accessile to the public next June. I desire now very briefly to state ıy principal conclusions. 1. The associated quartzite and staurote mica slates have been satisfactorily traced out to connect with he Coös group of New Hampshire, as was first suggested by 'rof. Dana (this Journ., III, vol. vi, p. 339). 2. The limestone does ot certainly dip beneath the quartzite. Had the section been rawn a few rods north the slates would be found to dip west and he quartzite standing on edge and the limestone concealed by oil. On the west side of the limestone is a west dip in the quartze. These facts suggest the possibility of a different interpretaion from that heretofore universally given. The limestone may e a remnant of a once extensive deposit covering both the other rmations mentioned, and what remains is in an inverted position. 'he limestone in Littleton overlies the quartzite. 3. If the Coös nd Helderberg strata are identical in age, the hornblende schist ear by and the gneiss of Vernon are not necessarily associated ith them, nor any of the great gneissic areas of New England. 'he Coös slates unconformably overlie the clay slates (Lower Siluian or Cambrian) of West Mountain and its continuation northard, as first suggested by Prof. Dana. These same slates rest pon the Quebec group of Logan in the Littleton region, and these ı their turn upon the same gneissic group as in Vernon. 4. Next o the Helderberg the Coös rocks are the newest in the Connectiut valley all the way to Canada; and if they can be proved idenical with each other, and also to include the enormous calcareous rea of Eastern Vermont and Canada, called "Calciferous micachist" in the Vermont Report, they show that all the rest of the orthern New England formations are older, and hence liable to be f any Eozoic series. 5. The Bernardston region abounds with xamples of inversions of the strata. It is impossible to propound ny consistent theory of structure here without them. The same s true for the whole of New Hampshire. 6. Further search in he Littleton region enables me to correct the statement of my revious article. I am satisfied that all the clay slates of Littleton re of the same age with those of West Mountain; hence at least hree-fourths of the area marked Helderberg on my map (p. 471), ıust be transferred to the other series. 7. The kinds and order of he Helderberg rocks are essentially alike in the Littleton and Berıardston fields; hence, by comparing the facts in both regions better

results are obtained than by reliance upon short sections in either one by itself.

Hanover, N. H., March 16, 1877.

4. *On Geological Time;* by T. MELLARD READE. Presidential Address before the Liverpool Geological Society. 28 pp. 8vo. Liverpool, 1877.—In this paper, Mr. Reade has used the analyses of river waters to determine the amount of mineral matter carried in solution from the land. He finds that the amount of water run off the area of England and Wales annually is 68,450,936,960 tons, equal to 18·3 inches in depth out of 31·988 inches of mean rainfall, leaving 13·7 inches for evaporation. The amount of solids in solution is 8,370,630 tons, or 12·23 parts in every 100,000 of water:—in which are about 9·50 parts of carbonate and sulphate of lime and magnesia, 1·66 of chloride of sodium, 0·08 of nitrates and 0·99 of alkaline sulphates and carbonate of soda, silica and sesquioxide of iron. Estimating the solids in solution at 15 cubic feet to the ton, the amount of denudation by solution would be ·0077 feet per century, or one foot in 12,978 years. Prestwich arrived at one foot in 13,200 years, for the amount of carbonate of lime which the Thames carries off from the Chalk, Upper Greensand, Oolitic strata and Marlstone. The Thames, estimating the discharge at 8 in. per annum, and the total solids at 29·26, as given by Prestwich, removes 147 tons per square mile per annum; and the denudation over England 143·5 tons.

Mr. Reade makes similar calculations for the rivers of Europe, and finds that the Rhine removes about 92·3 tons per square mile; the Rhone about 232 tons; the Danube about 72·7 tons; giving an average for the three rivers of 90 tons per square mile. The Garonne removes 142 tons per square mile; the Seine about 97 tons. From these data the conclusion is reached that probably over the world about 100 tons of rocky matter are dissolved by rain per English square mile per annum: of which, as near as can now be estimated, 50 tons may be carbonate of lime, 20 tons sulphate of lime, 7 silica, 4 each carbonate and sulphate of magnesia, chloride of sodium, and 6 alkaline carbonates and sulphates.

The amount of detritus brought down annually by the Danube is about $\frac{1}{3000}$ of the water, or three times the calculated amount of solids in solution; that of the Mississippi, according to Humphreys and Abbott, $\frac{1}{1321}$ of the water. Mr. Reade adds:

"If we were to take the solids removed mechanically at six times those in solution, which is a very high estimate, we should have over the whole of the globe 600 tons of denuded matter annually per square mile. Taking the sedimentary crust of the earth at ten miles thick throughout—a moderate estimate—and allowing for the denudation of the sea and the amount added to sediments by volcanic ejections, matter equal to one-third that which is denuded from the land, we should have annually removed and deposited matter equal to 800 tons per square mile of land surface, or 40,800 million tons annually. The total surface of the globe is 197 millions of English square miles. A cubic mile of rock at 13½ feet to the ton would weigh 10,903,552,000 tons, so that to cover the whole surface of the globe one mile deep with sediment from the land at the rate of 800 tons per square mile of land surface, would take 52,647,052 years, or 526 million years in round numbers for ten miles deep."

5. *The Carboniferous and Permian a continuous formation in Bohemia.*—A paper full of details as to fossils is published by Dr. Feistmantel in the Geological Magazine for March, in which the author proves that "in Bohemia (certainly also in other localities) there is no strict boundary between the Carboniferous and Permian; on the contrary, that these formations are in very close connection, as is shown in the association of a flora of Carboniferous character with animals mostly of Permian character, in the Gas-coals of the Pilsen and Kladno-Rakonitz basins." In the Pilsen coal-basin the gas-coal contains the Permian animal fossils, *Xenacanthus Decheni*, "one of the best Permian species," an *Acanthodes* near *A. gracilis* Röm., a *Palæoniscus*, *Uronectes* (*Gampsonyx*) and other species; and there are among fossil plants, *Lepidodendron dichotomum* Stbg., *Sagenaria elegans* Stbg., *Knorria*, *Lepidophyllum majus* Brgnt., *Sigillaria distans* Stbg., species of *Cyclopteris*, *Odontopteris*, *Neuropteris*, about nine Carboniferous species of *Sphenopteris*, four Carboniferous species of *Cyatheites*, three of *Alethopteris*, etc. Similar facts are reported from the other district referred to.

6. *Revue de Géologie pour les Années* 1874–1875, Vol. XIII; by M. Delesse, Ingenieur-en-Chef des Mines, et M. de Lapparent, Ingenieur des Mines, Prof. Geol. 252 pp. 8vo, with a colored agricultural chart of France showing its agricultural products, by M. Delesse. 1877.—From this valuable Geological Annual, bringing up the review of geological memoirs and discoveries to the middle of 1875, we cite the following:

Feldspathic rocks under the solvent action of water, carbonated waters and other reagents in solution.—M. Truchot subjected a series of Auvergne rocks in powder for several days to water charged with carbonic acid under a pressure of eight atmospheres, and obtained the following percentage results:

	Whole am't dissolved.	CaO removed.	K_2O removed.	P_2O_5 removed.
Granite of Montaigui	0·80	- - -	0·10	- - -
Granite of Trezioux	0·90	- - -	0·09	- - -
Lava of Volvic	1·75	0·25	0·08	trace
Domite, Puy de Dome	1·82	tr.	0·06	tr.
Trachyte of Mt. Dore	2·90	tr.	0·18	tr.

The trachyte was most readily attacked, especially its silica, and this accounts for the frequent occurrence of opal and other siliceous deposits in the fissures of this rock.

M. Cona, exposing the syenite of Bielle, finely pulverized, to water, dissolved 0·18 per cent at the ordinary temperature, and 0·42 at 100° C.; to water saturated with CO_2, dissolved 0·63 per cent; to water saturated with sulphate of lime, 0·43 per cent.

Orthoclase feldspar has been exposed to different solutions by A. Beyer, aided by Birner, Ulbricht and Heinrich (Arch. Pharm. II, cl, 193). A kilogram finely pulverized was put each time in two liters and a half of water or certain solutions, and kept so for about five months—out of contact with the air. The weight in grams dissolved in the 2½ liters of water for the different liquids was as follows:

	Equiv.	K_2O	Na_2O	CaO	MgO	$\bar{\mathrm{F}}\mathrm{e}, \bar{\mathrm{A}}\mathrm{l}$	SiO_2
Distilled water........	..	0·051	0·078	0·058	0·006	....	0·049
Carbonic acid in water	..	0·071	0·114	0·076	0·004	0·009	0·069
Lime	0·1	0·209	0·174	0·067	0·003	0·008	0·061
Magnesia	1·0	0·359	0·315	0·013	0·004	....	0·159
Magnesia and CO_2 ...	1·0	0·312	0·255	tr.	0·569	...	0·048
Gypsum	0·2	0·053	0·074	1·906	0·016	....	0·033
Sulphate of ammonium	0·2	0·161	0·094	0·122	0·035	....	0·066
Chloride of sodium...	0·2	0·163	....	0·091	0·008	0·004	0·032

The results are of much interest, showing that common salt and sulphate of ammonium, products that are usually in the soil, increase much the dissolving power of water; and still more do lime and magnesia—these bases separating the alkalies. Lemberg has shown that by the action of sulphate of magnesia on the zeolites, operating in closed tubes with heat, they were changed to hydrous silicates of magnesia; apophyllite being thus changed, losing in the process all but a few hundredths of its lime. Such facts are of great interest in connection with the subject of the origin of serpentine pseudomorphs.

7. *A fossil Saurian Vertebra from the Arctic Regions.*—Prof. A. Leith Adams has named the Saurian, a vertebra of which was brought from Rendezvous Point, Byam Martin Channel, by Admiral Sherard Osborn, *Arctosaurus Osborni.* It is "in all probability one of the middle cervicals of a Saurian with biconcave vertebræ," between ten and twelve feet long, agreeing "better with Lacertilia than Crocodilia." Sir Edward Belcher, Sir L. McClintoc, and Admiral Osborn brought many fossils from the group of islands lying between North Cornwall and North Devon. Among others were remains of Ichthyosaurus, determined by Prof. Owen, and said to be from Lias beds; and these are the only Arctic Reptilian remains hitherto described.

8. *Fossil Vertebrates from the Fort Union beds of Montana.*—Prof. E. D. Cope has described the following species in the Proceedings of the Philadelphia Academy of Natural Sciences, for 1876, p. 248: *Aublysodon lateralis*, *Lælaps incrassatus*, *L. explanatus*, *L. falculus*, *Dysganus encaustus* (a herbivorous Dinosaur), *D. Haydenianus*, *D. bicarinatus*, *D. peiganus*, *Diclonius pentagonus* (allied to *Hadrosaurus*), *D. perangulatus*, *D. calmarius*, *Monoclonius crassus* (near *Hadrosaurus*), *Paronychodon lacustris* (near *Plesiosaurus*), all based on specimens of teeth; also *Compsemys imbricarius*, *C. variolosus*, *Polythorax Missuriensis*, *Hedronchus Sternbergii*, *Ceratodus cruciferus*, *C. hieroglyphus*, *Myledaphus bipartitus.*

9. *A Text-book of Mineralogy, with an extended Treatise on Crystallography and Physical Mineralogy;* by EDWARD SALISBURY DANA, Curator in Mineralogy, Yale College. On the plan and with the coöperation of Prof. JAMES D. DANA. 486 pp. large 8vo, with over 800 wood-cuts and a colored plate. New York, 1877. (John Wiley & Sons, 15 Astor Place).—This work is intended for a class-book in the science. One half is occupied with the subjects of Crystallography, Physical Mineralogy, and Chemical and Determinative Mineralogy, and the other half with the Descriptions of species and a Catalogue of American localities. The subjects of crystallography and optical mineralogy are treated at much length in order that the student may have at hand the means of acquiring the special knowledge demanded for complete investigations; and illustrations and descriptions of the best instruments are given for the same purpose, besides numerous diagrams and figures of crystals. About seventy pages are devoted to descriptive crystallography, over twenty to mathematical crystallography after Nauman's system, and as many more to the same after Miller's system, each of which subjects is very fully illustrated by figures; and the chapter on optical characters extends to thirty-five pages. Besides, there are lists of recent works and memoirs on the various subjects considered under Physical Mineralogy.

The Descriptive part of the volume follows in its classification essentially that of the last edition of the system of Mineralogy, and is, in the main, a condensation of that work. But all new species introduced since the date of its publication have been inserted. The more important species—about half of all known—are described at length (though with few analyses, and often only the percentage composition), and the rest more briefly.

The preparation of this text-book, as the Preface states, was begun by Professor Dana shortly after the appearance of his larger work. But it was interrupted before the crystallographic part was completed; and in that state it has remained until taken up within the year past by Mr. Edward S. Dana. To Mr. Dana is due a revision of the crystallographic chapter, with some important modifications, the chapter on Miller's System, the section on Optical mineralogy, the notes on all new species, and a general review of the whole subject, bringing in results from recent publications.

For the full synonymy of the mineral species and the history of that synonymy, extended descriptions of American and foreign localities, tables of the many chemical analyses of minerals that have been made from the earliest times, notes on the alterations of minerals and occurring pseudomorphs, and some other points the reader will still have to look to the System of Mineralogy and its Supplements.

10. *Second Preliminary Report on the Mineralogy of Pennsylvania,* by F. A. GENTH; with analyses of mineral-spring waters. Harrisburg, 1876.—This is a report of progress, embodying the

work done upon the mineralogy of Pennsylvania during the year 1875. It contains a considerable number of new analyses, mostly of minerals, also of rocks, mineral waters and natural gases. Among other points Dr. Genth shows that the "*melanosiderite*" of Cooke is "not a good species, but simply an impure variety of hydrated iron sesquioxide, probably limonite." The "*cassinite*" from Blue Hill, Delaware Co., described by Lea as a variety of orthoclase, is shown to contain 3·7 p. c. baryta; the mean of three analyses gave: Silica 62·60, alumina 19·97, iron sesquioxide 0·12, magnesia 0·02, lime 0·19, strontia, tr., baryta 3·71, soda 4·43, potash 9·00, ignition 0·19=100·23. Specific gravity 2·692. E. S. D.

11. *Brief Notices of some newly described minerals. Ludlamite.*—Occurs in small monoclinic crystals, with distinct basal cleavage. Hardness 3·4. Specific gravity 3·12. Color clear green; transparent. Its composition is expressed by the formula $2Fe_3P_2O_8+H_2FeO_2+8aq$, which requires: Phosphorus pentoxide 29·88, iron protoxide 53·06, water 17·06=100. The formula of vivianite, to which it is related, is $Fe_3P_2O_8+8aq$. Ludlamite occurs in some of the mines of Cornwall, England, associated with vivianite, siderite, pyrite, arsenopyrite, etc.—(*Field, Phil. Mag.*, Jan., 1877.)

Strengite.—Occurs usually in spherical incrustations with a radiated structure, and a drusy surface; also rarely in orthorhombic crystals of tabular form. Hardness 3–4. Specific gravity 2·87. Color white, in some varieties bright carmine-red, in crystals also colorless. Transparent to translucent. Composition expressed by the formula FeP_2O_8+4aq, which requires: Phosphorus pentoxide 37·97, iron sesquioxide 42·78, water 19·25=100. In form and composition it is allied to scorodite ($FeAs_2O_8+4aq$). Strengite is found with cacoxenite at the iron mine Eleonore near Giessen.—(*Nies, Jahrb. Min.*, 1877, 8.)

Pelagite.—The name *pelagite* is given provisionally by Prof. A. H. Church to the material constituting the "manganese nodules" obtained by the Challenger in deep-sea soundings in the Pacific. An analysis afforded the following results: Manganese dioxide 30·22, iron sesquioxide 20·02, alumina 3·30, silica 10·37, chlorine 0·71, Mg, Ca, Na, etc., 0·83, water lost below 100° 24·55, lost at a red heat 10·00=100. It will be seen that the nodules, if homogeneous, have a complex chemical composition, and by no means consist essentially of "nearly pure peroxide of manganese," as had been reported. As stated by Prof. Church, the further analysis of additional material is needed before the name *pelagite* can be fairly accepted.—(*Church, Mineralogical Magazine*, No. 2, p. 50, Nov., 1876.)

Lawrencite.—M. Daubrée has given the name *lawrencite* to the protochloride of iron, the presence of which he has detected in the Greenland meteoric iron. It was earlier separated by Dr. J. Lawrence Smith from the Tennessee meteoric iron, and the name is given in honor of him.—(*C. R.*, Jan., 1877.)

Hydrocastorite.—G. Grattarola of Florence has observed a white mealy material surrounding the castorite of Elba, and he makes it a new mineral under the name hydrocastorite, it having been derived from the decomposition of castorite. It is in part compact, in part it is made up of an aggregate of fine needle-like crystals. Its composition is shown by the analysis: Silica 59·59, alumina 21·35, lime 4·38, water 14·66=99·98.

Guanajuatite.—The sulpho-selenide of bismuth from Guanajuato, Mexico, partially described by Castillo, (1873), and later fully described by Frenzel (Jahrb. Min., 1874, 679), was named *frenzelite* in the Second Appendix to Dana's Mineralogy (1875, p. 22). It seems, however, that the same mineral was at first named *guanajuatite* by Fernandez, who described it in full in the Guanajuato paper, "La República" for July 13th, 1873. The latter name should consequently be accepted instead of the name *frenzelite.* The description by Professor Fernandez differs from that of others in that he makes the mineral solely a bismuth selenide (Bi_2Se_3), and attributes the presence of a small amount of sulphur, shown in his analyses, to the admixture with a little pyrite. The material analyzed by Frenzel received the formula $2Bi_2Se_3+Bi_2S_3$.

Silaonite.—In the paper, "La República," for Dec. 23d, 1873, Professor Fernandez describes a second bismuth selenide from the same locality, the Santa Catarina mine at Guanajuato. It has a lead-gray color, and is compact in structure. Its hardness is a little less than that of calcite; its specific gravity 6·428 – 6·45. The results of several analyses upon material more or less pure led to the conclusion that the chemical composition is expressed by the formula Bi_3Se. E. S. D.

12. *Zeitschrift für Krystallographie und Mineralogie;* vol. i, No. 1, 1877.—The first number of this new Journal, recently received, admirably fulfills the promises made in the Prospectus. (See p. 162 of this volume.) It contains the following original articles: Mineralogical contributions by G. vom Rath; description of some immense enstatite crystals from Bamle, Norway, by W. C. Brögger and G. vom Rath; on the crystalline form of lanarkite, by A. Schrauf; on the regular grouping of quartz crystals on calcite, by E. S. Dana; on the dimorphism of hydrochinon and paranitro phenol, by O. Lehmann; a manganese variety of tremolite, by G. A. Koenig; on the form of crystals of barium sulphate, etc., by H. Baumhauer; on the schorlomite from the Kaiserstuhl, by A. Knop. In addition to the above articles, a series of notices and extracts, upwards of thirty in number, and covering as many pages, follow. These are derived from a great variety of sources, and form not the least valuable part of the number. Under the able editorship of Professor Groth, it cannot be doubted that the new Journal will always maintain the high character it has at its commencement. E. S. D.

13. *Ueber den inneren Zusammenhang der verschiedenen Krystallgestallten des Kalkspaths,* von Dr. F. SCHARFF; 61 pp. 4to, with five plates. Frankfort, 1876.—The memoirs previously published by Dr. Scharff upon the interior crystalline structure of several

mineral species, as quartz, feldspar, gypsum, have been most valuable contributions to the subject of Crystallogeny; and the same is eminently true of the present memoir upon Calcite. Dr. Scharff describes with great care and minuteness the results of his observations upon a large series of calcite crystals, and the descriptions are further elucidated by many excellent figures. His attention was especially directed to those cases in which the formation of the crystals was incomplete, or had been in some way interrupted, and from these sources he draws his conclusions as to the method of formation of the crystals, and the conditions determining their growth. E. S. D.

14. *Upon the Chemistry and Composition of the Porcelain and Porcelain-rocks of Japan;* by HENRY WURTZ.—Dr. Wurtz has published, in a recent number of the American Chemist, a paper of some length upon the porcelain-making of the Japanese, prepared by him in his capacity as Judge in one of the departments of the Centennial Exhibition. He gives a description of the occurrence of the materials in Japan, and the methods employed in the preparation of the porcelain from them. The chemical composition of both the natural materials in their different varieties and the manufactured products are also given at length in a series of analyses.

III. BOTANY AND ZOOLOGY.

1. *Dictionnaire de Botanique, par* M. H. BAILLON, Paris. (Hachette & Cie.)—We noticed the first fascicle at the time of its appearance. The second and third are now received, reaching to p. 240, and to the article *Apothecium;* so that about 300 pages will be devoted to the first letter of the alphabet. The work must needs be voluminous, for it is a veritable encyclopedia, and various articles have developed almost into treatises, with profuse and excellent wood-cut illustrations. The main articles of this sort in the present fascicles are *Albumen*, *Aleurone*, *Algæ*, *Aliments des plantes*, *Alternance des générations*, *Amidon* (starch), *Androcée* (which should be, as M. Littré says, *Andrœcie*, under which synonym only is the proper derivation given), *Anthère*, *Antheridie*, and *Antherozoides*. The work improves as it advances, and if in danger of being too bulky, it is certainly low-priced, considering execution, and fullness of illustration.

Under *Ainsliœa*, by some mischance, it is said that to this imperfectly known genus, *Parthenice* Tor. & Gray probably belongs; and over the leaf there is something equally confounding under *Aiolotheca*. The explanation is that the last five lines of the two articles have been accidentally transposed in manuscript or type, and then one word altered in proof-reading. A. G.

2. *Flora Fossilis Arctica; Die Fossile Flora der Polarländer*, von Dr. OSWALD HEER, Vierter Band, mit 65 Tafeln, 4to, Zurich, J. Wurster & Comp. 1877.—This fourth volume of a classical, and to us particularly interesting work, is a collection of three memoirs.

First, Beiträge zur fossilen Flora Spitzbergens; with a geological appendix, by Prof. Nordenskiöld. This belongs to the fourteenth volume of the memoirs of the Royal Swedish Academy of Sciences, Stockholm, no. 5, issued in 1876.

Second, Beiträge zur Jura-Flora Ost-Sibiriens und des Amurlandes, is from the memoirs of the Imperial Academy of Sciences, of St. Petersburg, vol. xxii, issued in 1876.

Third, A small part, with only two plates, Ueber die Planzen-Versteinerungen Von Andö in Norwegen, apparently has not elsewhere appeared.

This East Siberian Jurassic flora is rich in Gingkos (seven species), with some allied Taxineous genera, as well as some *Taxodieæ*, more *Abietineæ*, and three Monocotyledons (*Pandaneæ*). The Spitzbergen deposits referred to that era, furnish six or seven species or forms of Gingko, three Pines, and a sort of Bamboo; the Cretaceous, three or four Pines, Sequoias, a *Torreya*, etc.; and the Miocene has *Taxodium*, *Glyptostrobus*, *Sequoia*, *Cyperus*, *Carex*, *Maianthemum*, *Alisma*, seven Poplars, two Alders, three Hazels, a Hornbeam, a Beech, four Oaks, an Elm, a Plane-tree, an Ivy, five species of *Cornus*, two of *Nyssa*, and a *Nyssidium*, two of *Magnolia*, a *Parrottia*, a *Tilia*, three Maples, a *Kœlreutera*, three Hawthorns, and a veritable fossil strawberry! A. G.

3. *Proceedings and Transactions of the Nova Scotia Institute of Natural Science*, vol. iv, part 2, 1877.—This part is rather rich botanically. Professor Sommers institutes an elaborate comparison between the flora of Nova Scotia and that of Colorado. Rev. E. H. Ball, gives an interesting and readable account of the Ferns of Nova Scotia. Prof. Lawson, in notes upon some Nova Scotian plants, takes up the *Calluna vulgaris* question, enumerates the known stations in the provinces, and the circumstances and condition of most of them; and concludes that while one or two of them may be artificial, "it has been originally a native indigenous plant," and "that the various traditions as to the foreign origin of the heather, are not unlikely to have been suggested by the desire to account for the presence of what was regarded as necessarily a foreign plant, rather than by actual historical facts." There are several communications relating to *Rhododendron maximum*, which has its northern and eastern limit in Nova Scotia. Finally, Professor Sommers gives a catalogue of the plants of the Province.

A. G.

4. *Lady Smith*, the widow of Sir James Edward Smith, and his survivor for almost half a century, died on the third of February last. She was born, May 11, 1773. An authenticated copy of the register of her baptism was printed in the London Times (which has been skeptical about centenarians) along with an interesting biographical notice. There is no room for doubt that, if she had survived three months longer, she would have been 104 years old. She not only lived long but enjoyed life to the last. She wrote a clear and firm hand, at least up to her hundredth year; her eyesight of late failed only so far that she was unable longer to read or guide her pen; "her hearing was at worst only a little hard," her teeth were almost perfect, and her memory was nearly unimpaired. Since Dr. Torrey's death, probably the only surviving

correspondent of her husband is Dr. Jacob Bigelow, who on the 27th of February attained the age of 90. A. G.

5. *Joseph de Notaris*, the distinguished Italian Bryologist, who was born on the 5th of May, 1805, and who was lately transferred from the chair of botany in the University of Genoa, to that at Rome, died on the 22d of January last. A. G.

6. *Recent Papers on Fungi.*—The following are articles of interest, which have recently appeared:

(1.) *Reproduction des Ascomycetes*, par M. MAX CORNU,—Annales des Sciences Naturelles, 6^e Série. Tome iii.

(2.) *Beiträge zur Kenntniss der Pycniden* 1; von Dr. HERMANN BAUKE.—In the two papers by Cornu and Bauke, an attempt has been made to discover the nature of the organs known as *spermatia*, *stylospores*, and *pycnidia*. The two last named organs, since the publication of Tulasne's Carpologia, have been generally admitted to be secondary forms of species of Ascomycetes. Certain cases, however, seemed to point to the conclusion that some pycnidia were independent organisms, and it was to settle this point that Dr. Bauke made his investigations. His method consisted in the artificial cultivation of different spores, and resulted in a general confirmation of Tulasne's views. The observations of Cornu have extended over several years; and, in regard to the spermatia, he comes to the conclusion that they cannot be considered male organs. He has observed that they germinate, and thinks that they must be regarded as a form of stylospore. Although contrary to the view generally maintained as to the nature of spermatia, and to the views expressed by Stahl in the Bot. Zeitung, Mar. 20, 1874, Cornu's view coincides with what has recently been published in the Bot. Zeitung and Comptes Rendus with regard to the supposed spermatia of species of Coprinus by Brefeld and Von Tieghem. The reason why the germination of spermatia has not been seen until recently is explained by Cornu by the fact that most cultures of spermatia have been made with pure water, whereas the presence of some special nutritive fluid, as solution of gum, bark, etc., seems to be necessary. Cornu was led to this conclusion by noticing that, when sown on a glass slide, under a cover-glass, the spermatia germinated more readily on the side next the gummed label.

(3.) *Ueber den Gitterrost der Birnbäume und seine Bekämpfung;* von Dr. G. KRAMER; An interesting paper in the Schweizerische landwirthschaftliche Zeitschrift on a disease of pear trees, caused by *Rœstelia cancellata* Rebent, which Dr. Kramer agrees with Oersted in considering a form of *Podesoma fuscum* Duby occurring on *Juniperus sabina*, L. W. G. F.

7. *Destruction of Forest Trees by Mistletoe;* by E. S. CROZIER. (From letter to Editors dated Louisville, Ky., March 9, 1877.)—The American Mistletoe (*Phoradendron flavescens*) is very common in this latitude (38°), and bids fair to become an important factor in the forest culture of regions favorable to its growth. It grows luxuriantly upon the branches of the elm and black walnut; and it has increased to such an extent that large forests of the latter

are now almost destroyed. In many sections this valuable timber has entirely disappeared; and in others the branchless trunks, still standing, attest the destructive effects of this parasite. As soon as a bunch of mistletoe fixes itself upon a branch, the outward extremity ceases to grow, and finally dies. The tree soon presents a clubby appearance, followed by death. A grove of black walnuts, just east of this city, was notable a few years ago for its depth of foliage and the thrifty growth of its individuals. It is now a picture of desolation. A few years will witness its total destruction. The importance of this subject to the industrial interests of the country should commend it to the attention of those interested in arboriculture, in the hope that some means may be devised for preventing the ravages of this parasite.

8. *Median and Paired Fins, a Contribution to the history of Vertebrate Limbs;* by JAMES K. THACHER.—This memoir is from volume iii of the Transactions of the Connecticut Academy. It is the result of a careful comparison of the fins of various species of fishes at early stages of growth, and is illustrated by twelve plates. The view reached is in opposition to that of Gegenbaur on the subject, and is expressed thus:

As the dorsal and anal fins were specializations of the median folds of Amphioxus, so the paired fins were specializations of the two lateral folds which are supplementary to the median in completing the circuit of the body. These lateral folds, then, are the homologues of the Wolffian ridges, in embryos of higher forms. Here, as in the Median fins, there were formed chondroid and finally cartilaginous rods. These became at least twice segmented. The orad ones, with more or less concrescence proximally, were prolonged inwards. The cartilages spreading met in the middle line, and a later extension of the cartilages dorsad completed the limb girdle.

If now we seek to determine the form of limb for the Protognathostomi, that is to say, for that time for which the archipterygium in its entirety is proposed, we should propose this:

The limbs of the Protognathostomi consisted of a series of parallel articulated cartilaginous rays. They may have coalesced somewhat proximally and orad. In the ventral pair they had extended themselves mesiad until they had nearly or quite met and formed the hip girdle. They had not here extended themselves dorsal. In the pectoral limb the same state of things prevailed, but was carried a step further, namely, by the dorsal extension of the cartilage constituting the scapular portion, thus more nearly forming a ring or girdle.

IV. ASTRONOMY.

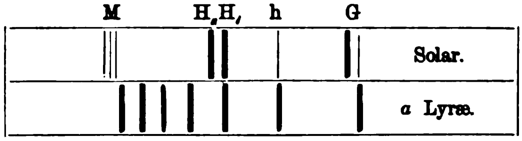
1. *Elements of Borelly's Comet;* by AARON N. SKINNER, Assistant U. S. Naval Observatory. (From a letter to the editors, dated Washington, D. C., March 13, 1877.)—I have deduced the following elements of Borelly's Comet from equatorial observations made at this Observatory, February 9, 12 and 17.

$$\begin{aligned} T &= 1877,\ \text{Jan. } 18\cdot9658,\ \text{Wash. M. T.} \\ \pi &= 174^\circ\ 15'\ 32'' \\ ☊ &= 187\ \ 10\ \ \ 4 \\ i &= 152\ \ 20\ \ 28 \\ \log g &= 9\cdot90709 \end{aligned} \left.\vphantom{\begin{aligned}a\\a\\a\end{aligned}}\right\} \text{Apparent Equinox, Feb. } 13\cdot7.$$

The constants for computing the rectangular coördinates are:

$$\begin{aligned} x' &= 9\cdot90639 \sin(250^\circ\cdot7068+v) \sec^2 \tfrac{1}{2}v \\ y' &= 9\cdot71223 \sin(336^\circ\cdot7634+v) \sec^2 \tfrac{1}{2}v \\ z' &= 9\cdot79456 \sin(343^\circ\cdot4010+v) \sec^2 \tfrac{1}{2}v \end{aligned}$$

2. *Note on the Photographic Spectra of Stars;* by WILLIAM HUGGINS, D.C.L., LL.D., F.R.S. (From the Proceedings of the Royal Society, No. 176, 1876).—In the year 1863 Dr. Miller, and myself obtained the photograph of the spectrum of Sirius. "On the 27th January, 1863, and on the 3d of March of the same year, when the spectrum of this star (Sirius) was caused to fall upon a sensitive collodion surface, an intense spectrum of the more refrangible part was obtained. From want of accurate adjustment of the focus, or from the motion of the star not being exactly compensated by the clock movement, or from atmospheric tremor, the spectrum, though tolerably defined at the edges, presented no indications of lines. Our other investigations have hitherto prevented us from continuing these experiments further; but we have not abandoned our intention of pursuing them."* I have recently resumed these experiments by the aid of the 18-inch speculum belonging to the Royal Society's telescope in my possession. Considerable delay has arisen from the necessity, for these observations, of a more uniform motion of the driving-clock. For this purpose, Mr. Howard Grubb has successfully applied to the clock the control of a seconds pendulum in electric connection with a sidereal clock. This system works quite satisfactorily. The prisms employed are made of Iceland spar, and the lenses of quartz. After an extensive trial of different photographic processes, preference has been given to dry plates. The apparatus is so arranged that a solar or electric spectrum can be taken on the same plate, for the purpose of comparison, with the spectrum of the star. Spectra have been obtained of Sirius, Vega, Venus, the Moon, etc. I do not purpose in this preliminary notice to describe in detail the arrangements of the special apparatus which has been constructed, nor to offer the results of the experiments in their present incomplete state to the Royal Society. Still I venture to hope that, even in this early stage of the inquiry, the enlarged copy of the spectrum of Vega (α Lyræ) which accompanies this note may not be regarded as altogether unworthy of



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* Phil. Trans., 1864, p. 428.

attention. After exposure to the light of Vega, the dry plate was allowed to remain in the instrument until the following morning, when a solar spectrum was taken upon it, through the half of the slit which had remained closed when the instrument was directed to the star. The photograph shows seven strong lines, all of them slightly shaded at the sides. The two lines which are least refrangible coincide with two known lines of hydrogen in the solar spectrum. It is expected, by means of an apparatus now in the course of construction, to obtain also any finer lines which may be present in the spectrum of this star, as well as to extend the photographic method to stars which are less bright. I need not now refer to the many important questions in connection with which photographic observations of stars may be of value.

3. *Tables of the Satellites of Jupiter;* by D. P. TODD. 40 pp. 4to.—Published for the American Ephemeris by authority of the Secretary of the Navy. The tables of Damoiseau published in 1836 give the places of Jupiter's satellites up to the year 1880. The present tables are a continuation of Damoiseau's by the same formulæ and elements to the year 1900.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Geological Society of London.*—At the Annual Meeting, February 16th, the Wollaston Gold Medal was presented by the President of the Society, to Mr. ROBERT MALLET, for his able researches on earthquakes, volcanoes, volcanic energy, and other important scientific labors; the Murchison Medal to Rev. W. B. CLARKE, of Sydney, Australia, for his various geological discoveries during the half century past in New South Wales; the Lyell Medal and part of the Lyell Fund to JAMES HECTOR, Director of the Geological Survey of New Zealand; the balance of the proceeds of the Lyell Fund, to Mr. PENGELLY, for his explorations of Kent's Cavern.

At the same time the Bigsby Medal, founded last year by Dr. Bigsby, F.R.S., F.G.S., formerly an able worker in the geology and paleontology of British North America, was given to Prof. O. C. Marsh, of Yale College, "in recognition of the great services which Prof. Marsh has rendered to the paleontology of the Vertebrates;" whose studies include "fossil remains of nearly every great group of the Vertebrata from the Paleozoic, Cretaceous and Cenozoic strata of the New World," and "are so numerous and so important as to mark an epoch in this line of research."

2. *Bulletin of the Buffalo Society of Natural Sciences*, vol. III, No. 4. 1877.—This number of the bulletin contains a check-list of the fresh-water fishes of North America (concluded) by D. S. Jordan; the Shinumos, by F. S. Dellenbaugh; on the peopling of America, by A. R. Grote; on the Hyphomecetous Fungi, by M. C. Cooke. Mr. Grote's paper applies the idea respecting the migrations of species in consequence of the

approach and retreat of the cold and ice of the Glacial era (which has been illustrated by different authors with respect to plants and animals generally, and in Europe as regards man) to man in North America, but without any special facts in proof of the suggested migration.

3. *The California State Geological Society* "has been recently incorporated for the purpose of making a collection of mineral products of the Pacific coast," promoting the progress of economic Geology, and "encouraging the study of Geology in all its branches." The President of the Society is Mr. HENRY G. HANKS, and the Secretary S. HEYDENFELDT, Jr.

4. *Meteorology of Golden, Colorado*, in lat. 39° 44′ 24″ N., long. 28° 8′ 10″ W., 5,618 feet above the sea.—Mean temperature for 1876, 51·64° F.; precipitation 18·36 in.; mean temperature of the warmest day 80·7° F.; do. of the coldest day (March 10) 8° F. above zero; mean temperature of the winter months, 36·18° F.; spring, 45·90; summer, 69·90; autumn, 54·60; winds between N.E. and S.E. 20 to 30 days for the several seasons, and between W., S. and S.E. 20 to 30 days for the several seasons, and between N. and S.W., 57 to 72 days for the seasons.—*E. L. Berthoud, in Colorado Transcript* for Jan. 10.

5. *The American Microscopical Society of the City of New York.*—At the annual meeting held January 9th, the following officers were elected for the ensuing year: President, John B. Rich, M.D., 1 West 38th street, N. Y.; Vice-President, Wm. H. Atkinson, M.D., 41 East 9th street, N. Y.; Secretary, O. G. Mason, Bellevue Hospital.

6. *Remarks on the Structure of Precious Opal.*—Prof. LEIDY has an article in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1876, p. 195, on the microscopic structure of the opal of Queretaro, Mexico.

7. *Shoal in the Atlantic* 300 *to* 400 *miles northeast of Madeira and* 130 *miles from Cape St. Vincent.*—Commander Gorringe, of the United States sloop Gettysburg, has discovered a bank in 36° 29′ N. and 11° 33′ W. with only thirty-two fathoms water over it, and 1525 fathoms to the southeast and southwest of it. It is about 200 miles west of the Josephine Bank which has a depth of eighty-two fathoms, and lies nearly in a line between Madeira and Cape St. Vincent. *Nature*, of March 1, gives a map of that portion of the Atlantic from Capt. Gorringe's soundings and those of the Challenger, in January, 1873, and the German frigate Gazelle, in 1874.

OBITUARY.

WOLFGANG SARTORIUS VON WALTERSHAUSEN, the distinguished author of works and memoirs on volcanic rocks, minerals, and phenomena, including extended treatises on those of Iceland and Etna, and Professor of Mineralogy and Geology in the University of Göttingen, died on the 16th of October last, at the age of nearly sixty-seven. He was the author also of memoirs on terrestrial magnetism, meteorology and paleontology.

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[THIRD SERIES.]

ART. XXXVII.—*On Vortex Rings in Liquids;* by JOHN TROWBRIDGE, S.D., Assistant Professor of Physics. (*Contributions from Physical Laboratory of Harvard College.* No. XVIII.)

[Presented at the Meeting of the Am. Acad. of Arts and Sciences, Mar. 14, 1877.]

IT has often been observed by chemists that a drop of colored liquid falling from a burette into a liquid of a different specific gravity, in which it can diffuse, assumes the form of a ring. Vortex motion, by the researches of Helmholtz, Thomson, Rankine, and Maxwell, is now attracting so much attention, that I have thought that a study of the general equations of motion of matter in connection with a study of these rings would contribute to our knowledge of vortex movement.

Prof. W. B. Rogers published in this Journal, xxvi, 1858, a paper on smoke rings and liquid rings, and described several methods of studying them. In Professor Tait's "Recent Advances in Physical Science," a method of forming smoke rings is given. The apparatus consists merely of a large box closed at one end by a thin sheet of india rubber, or with a tightly stretched towel, and having a circular opening of six or eight inches in diameter at the other. Clouds of sal-ammoniac vapor are generated inside the box, and rings are expelled from the circular opening by a blow upon the rubber or towel. Sir William Thomson suggests that two such boxes placed so that the rings may impinge on each other at any angle would form a useful apparatus for studying the behavior of such rings toward each other. At the conclusion of this paper, several methods of studying liquid rings will be described. When a drop of liquid falls from a short distance into a liquid of less density, in which it cannot diffuse, the conditions of its motion just after the instant of its striking the surface of the liquid of less density are indicated by the general equations of heterogeneous strains.* "For each particle we have the component velocities u, v, w, parallel to the fixed axes OX, OY, OZ. These have the following expressions:

$$\text{Eq. (1)}: \ u=\frac{d\alpha}{dt}, \qquad v=\frac{d\beta}{dt}, \qquad w=\frac{d\gamma}{dt};$$

x, y, z, t being independent variables, and α, β, γ, functions of them. If the disturbed condition is so related to the initial condition that every portion of the body can pass from its initial to its disturbed position and strain, by a translation and a strain without rotation,—i. e., if the three principal axes of the strain at any point are lines of the substance which retain their parallelism,—we must have—

$$\text{Eq. (2)}: \ \frac{d\beta}{dz}=\frac{d\gamma}{dy}, \qquad \frac{d\gamma}{dx}=\frac{d\alpha}{dz}, \qquad \frac{d\alpha}{dy}=\frac{d\beta}{dx};$$

and, if these equations are fulfilled, the strain is now rotational, as specified." But these equations express that $\alpha dx+\beta dy+\gamma dz$, is the differential of a function of three independent variables; and therefore, in order that there may be no rotation, a strain potential must exist. The forces which solicit the particles of the drop when it rests upon the liquid of less density in which it cannot diffuse are evidently their mutual attraction, a force arising from the superficial tension of the liquid, and one arising from gravitation. It is evident, from a consideration of these forces, that, after the drop has suffered a strain at the surface, every portion of the drop cannot pass from its initial position to the next following by a translation and a strain without rotation. For the drop tends to return from a shape approaching an oblate spheroid to that of a sphere. Equations (2) do not hold, and a strain potential does not exist, and therefore this drop must rotate. This rotation is not in general of the ring form. If, on the other hand, the drop of liquid can diffuse itself in the liquid through which it falls, each particle with the velocity u, v, w, is solicited at the moment of impact by a superficial tension, by the force of gravitation, and by a force arising from the rate of diffusion. In this case, there is no tendency of the body to reassume the spheroidal or spheroid form in its passage through the liquid. On the other hand, to assume that each particle in the next state of the drop very near that which it assumes on striking the free surface of the liquid of less density, is translated without rotation, is to assume that each particle is compelled to move in restrained limits which do not exist. For the components X^1, Y^1, Z^1, of the attraction, which tend to make the non-diffusible drop reassume its spherical form, we have in the case of the diffusible the components X, Y, Z, of an external force arising from the superficial tension of the liquid, and the impulse given to the drop.

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* Thomson and Tait's Natural Philosophy.

If we follow the notation of Poisson* and Helmholtz,† we shall have for the general equations of internal motion of a liquid:

$$\left.\begin{aligned} X - \frac{1}{h}\frac{dp}{dx} &= \frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz} \\ Y - \frac{1}{h}\frac{dp}{dy} &= \frac{dv}{dt} + u\frac{dv}{dx} + v\frac{du}{dy} + w\frac{du}{dz} \\ Z - \frac{1}{h}\frac{dp}{dz} &= \frac{dw}{dt} + u\frac{dw}{dx} + v\frac{dw}{dy} + w\frac{dw}{dz} \end{aligned}\right\} \quad (3)$$

$$\frac{dh}{dt} + u\frac{dh}{dx} + v\frac{dh}{dy} + w\frac{dh}{dz} = \frac{\delta h}{\delta t} \quad (4)$$

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0 \quad (5)$$

In which p is the pressure in a liquid at the point x, y, z; X, Y, Z, are the components of the external forces acting on a unit of mass; and h is the density. When the variation of h is infinitely small, we have Eq. (5). The forces X, Y, Z, are considered to have a potential V. So that

$$X = \frac{dV}{dx}, \qquad Y = \frac{dV}{dy}, \qquad Z = \frac{dV}{dz} \quad \text{Eq. (6)}$$

and the velocities u, v, w, a velocity potential Φ. So that

$$u = \frac{d\varphi}{dx} \qquad v = \frac{d\varphi}{dy} \qquad w = \frac{d\varphi}{dz} \quad \text{Eq. (7)}$$

or
$$udx + vdy + wdz = d\varphi,$$

and φ satisfying the equation

$$\frac{d^2\varphi}{dx^2} + \frac{d^2\varphi}{dy^2} + \frac{d^2\varphi}{dz^2} = 0$$

which is what equation (5) becomes under the conditions expressed above. We must therefore have

$$\frac{du}{dy} = \frac{dv}{dx}, \qquad \frac{dv}{dz} = \frac{dw}{dy}, \qquad \frac{dw}{dx} = \frac{du}{dz} \quad \text{Eq. (8)}$$

equations similar to the equations expressing a strain potential. Helmholtz has shown that in the case of rotation of a fluid element, Eqs. (8) become

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* Traité de Mechanique.

† Crelle's Journ., lv, 1858.

$$\left.\begin{aligned}\frac{dv}{dz}-\frac{dw}{dy}&=2\xi\\ \frac{dw}{dx}-\frac{du}{dz}&=2\gamma\\ \frac{du}{dy}-\frac{dv}{dx}&=2\zeta\end{aligned}\right\}\qquad \text{Eq. 9.}$$

and therefore "the existence of a velocity-potential is inconsistent with the existence of rotation of the fluid element." We have seen from the equation of strain that the existence of a strain potential is inconsistent with the rotation of a material particle. Let us now see if vortex movement can arise in a liquid from variation of density and pressure. Following Helmholtz's notation, we have, if ψ is a function of x, y, z, t,

$$\frac{\delta\psi}{\delta t}=\frac{d\psi}{dt}+u\frac{d\psi}{dx}+v\frac{d\psi}{dy}+w\frac{d\psi}{dz}\qquad \text{Eq. (10).}$$

Calling ξ, γ, ζ, the components of the angular velocity, we can obtain their variations by substituting them in succession in Eq. (10). If we eliminate X, Y, Z, from Eqs. (3) by the help of Eqs. (6), supposing that h and p are functions of x, y, z, t, we obtain, introducing the values of ξ, γ, ζ, from Eqs. (9):

$$\text{Eq. (11).}\ \frac{\delta\xi}{\delta t}=-\xi\left(\frac{dv}{dy}+\frac{dw}{dz}\right)+\gamma\frac{dv}{dx}+\zeta\frac{dw}{dx}+\frac{1}{2h^2}\left(\frac{dh}{dz}\cdot\frac{dp}{dy}-\frac{dh}{dy}\frac{dp}{dz}\right)$$

and similar expressions for the variations of γ and ζ. If the variation of h is infinitely small, we obtain by the aid of Eq. (5):

$$\frac{\delta\xi}{\delta t}=\xi\frac{du}{dx}+\gamma\frac{dv}{dx}+\zeta\frac{dw}{dx}$$

If it is not infinitely small, we have the term

$$\frac{1}{2h^2}\left(\frac{dh}{dz}\frac{dp}{dy}-\frac{dh}{dy}\frac{dp}{dz}\right)$$

which is independent of ξ, γ, ζ, and depends upon the variation of h and p. This term enters into the expressions for the variations in the angular velocities; and shows, therefore, that a vortex movement can arise in a process of diffusion by a variation in density and pressure, without the aid of initial angular velocities. This condition can be shown experimentally by dropping a somewhat dense solution of one of the aniline colors into a mixture of glycerine and water. The original ring, after ceasing to move downward in the mixture, breaks up gradually into segments, which slowly in their turn assume the ring form. A mixture of water and glycerine is not necessary: peculiar cusp-like figures indicating the first stage of vortical movement can be seen whenever a thin stratum of one liquid slowly diffuses itself through another liquid of different density.

By a consideration of the equations—

$$\varepsilon\xi + (u_1 - u)dt = \varepsilon\left(\xi + \frac{\delta\xi}{\delta t}dt\right)$$

$$\varepsilon\gamma + (v_1 - v)dt = \varepsilon\left(\gamma + \frac{\delta\gamma}{\delta t}dt\right)$$

$$\varepsilon\zeta + (w_1 - w)dt = \varepsilon\left(\zeta + \frac{\delta\zeta}{\delta t}dt\right)$$

given by Helmholtz, from which he draws the conclusion that "each vortex line remains continually composed of the same elements of fluid, and swims forward with them in the fluid," we see, on introducing the new expressions which we have found for $\frac{\delta\xi}{\delta t}$, &c., Eq. (11), that we approach nearer and nearer to this theoretical conclusion when the variations of h are smaller and smaller. Obviously, we should then obtain the most perfect rings when the drop and the liquid in which the motion takes place are composed of the same liquid. And, *therefore, a drop of water falling into water must form a more perfect ring than that formed by a drop of any colored liquid of greater density than water.*

The formation of these liquid rings is as fascinating and as simple an occupation as blowing soap-bubbles. All liquids falling from such a height that the surface of the liquid is not too much disturbed to enable the drop to be acted upon symmetrically by the forces at the free surface will form rings, if too great differences of density do not exist, and if the drop can diffuse in the liquid. The preceding mathematical discussion, as we have seen, shows us that a drop of pure water on striking the same element under the above conditions must necessarily assume the ring shape. This can be shown experimentally by covering the free surface of the water with a fine powder, or with matter in a fine state of subdivision. I have found that an alcoholic tincture of ginger, which gives on the surface of water a milky liquid consisting of particles in a fine state of subdivision, answers the purpose very well. Fine particles will be carried down by the drop, and will be seen to rotate in a vortex ring far below the surface. This fact can be stated, also, by the employment of any of the aniline colors which are solvent in water, the falling drop consisting of a colored solution, whose specific gravity does not differ sensibly from that of water. The method that I have employed to produce the rings consists merely of a small glass tube, slightly smaller at one end than the other. A bit of cotton is wedged in nearer the larger end, over which a piece of flexible rubber tubing is slipped. With the aid of the mouth, one can fill this tube with liquid and eject it in drops at pleasure. The same apparatus enables us to form the rings beneath the surface of the liquid. With a tube bent horizontally, one can send the rings through a liquid in any desired direction; and, by means of a three-way glass joint and a small india-rubber bag, one can send forth, by the same impulse, two rings whose paths make any desired angle with each other. By partly immersing the glass tubes connected with the three-way tube in the free surface of the liquid, and covering the surface of the water with fine powder, one can study the mutual behavior of half vortex rings. A simpler method is to illuminate, by means of a gas-light, the bottom of a flat, white porcelain dish filled with water, and to observe the shadows of the half-vortex rings on the bottom of the dish formed by the movement of two spatulae along the surface. It can be readily seen, by this simple method, that a half-vortex ring moving near another in a parallel path and with a less velocity tends to follow in the path of the first; and that two equal half-vortex rings moving in opposite directions along the same path separate into two vortices which move at right angles to the path of the original vortices. We can conclude, also, from this general discussion, that, whenever a mass of vapor of greater density than the surrounding air is suddenly formed in the higher regions of the atmosphere, it tends to descend through it in a vortex ring.

The results of the preceding discussion are as follows:

1. An analogy between the strain potential and the velocity potential is indicated.
2. It is shown that the formation of liquid rings is a necessary result of the fundamental equations of strains and those of hydrodynamics; and that they constitute a general and not a special phenomenon. A drop of water falling into water from a suitable height must assume a ring shape.
3. Vortices can and do arise in certain processes of diffusion.
4. Simple methods of studying vortex motion in liquids are given.

ART. XXXVIII.—*An account of the Discoveries in Vermont Geology of the* Rev. AUGUSTUS WING; by JAMES D. DANA.

THE death of the Rev. Augustus Wing, in January, 1876, deprived the country of an excellent geological observer, and science of the results, to a large extent, of his long labors.* During the preceding summer, in July, I had the pleasure of an excursion with him to various localities over the country between

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* See this Journal, III, xi, 334.

Rutland and Monkton, Vermont, and derived much profit from the survey of the region he had explored, and from the information he communicated in conversation. When we parted he promised to prepare a paper containing the results of his observations for publication. His decease having prevented the accomplishment of his purpose, I have felt it a duty to him and to science to consent to perform, with the aid of such material as I could obtain, the unfulfilled task; and the following article is the result.

My sources of information have been two small note-books and a few of his letters, received from his family through Prof. Henry M. Seely, of Middlebury College. But these letters are, in part, long accounts of his geological observations and views, written at different times during the ten years over which his explorations extended,—probably in response to enquiries from those to whom they were addressed. Among them, one, of many pages, bearing the date, August 9, 1872, is addressed to me, and was written, as it states, on receiving a request from me, dated August 3, for "a fuller account of the fossils of West Rutland," a brief note on his discoveries by Mr. E. Billings, being all hitherto published. No copy of this letter ever left his hands, nor even an acknowledgment of the request; and it is probable that the same is true of the others. His disinclination to write, and his reluctance to make his results public, so long as doubts remained, were, in all probability, the occasion of these many unfinished epistles. But if hesitating with his pen, he was all energy and enthusiasm in exploration. It was in 1865 that he came to the determination "to ascertain, if possible, the geological age of the limestones, slates and quartzytes of Otter Creek Valley;" and ever afterward he kept at it, "tramping," as he says, "during all the time that could be spared from vigorous teaching." He had his reward while going on with his work; for, as his writings show, he experienced the delight of a child over his discoveries; and, at the same time, he felt the confidence of a thorough worker, that the geological truths developed would sooner or later find their place in the science. He continued his field-work to the last; and it was the fatigue of an excursion in the autumn of 1875, when he was already sixty-seven years old, that brought on his fatal illness.

It is to be regretted that his results were not earlier made public; for they would have given some errors in New England geology a speedier extinction, and helped much to push forward discovery. Mr. Wing, by the use of his spare time amid the duties of teaching, accomplished vastly more for the elucidation of the age of Vermont rocks than had been done by the Vermont Geological Survey. The Vermont Report presents diverse opinions about the Eolian limestone and the formations adjoining, but settles nothing; while Mr. Wing's discov eries shed light not on these rocks alone, but also on the ge eral geology of New England and Eastern North America.

In preparing the following account of his results I have used mainly his letter to me of August, 1872, it being the latest detailed statement of his researches left by him, and it giving his facts and views quite fully in the course of its sixty-two pages. But his earlier and later notes also have furnished some facts. All remarks of my own, or additional facts from others, which are introduced beyond, are put in smaller type.

1. *The Region.*

The region studied by Mr. Wing is part of the area of the crystalline limestone formation of Middle and Southern Vermon —the "Eolian limestone," as named by Hitchcock, in the Ve mont Geological Report.* This limestone covers a wide ce tral north-and-south strip of country, extending from the south ern boundary of the State to Northern Monkton—a distance o about one hundred miles. The limestone region is border on the east almost continuously by ridges of quartzyte, quartzyte and slates, which extend along the western foot the Green Mountains. Besides, there are north-and-sou dividing ridges or belts of hydro-mica slate† and clay-slat with sometimes interstratified quartzyte. On the west the are, in some parts, other belts of the slate, and to the north, near the great fault, areas of the Red Sand-rock. These vari ous rocks are so associated that the study of all is involved that of the Eolian limestone. Moreover they together extend southward into and through Massachusetts.

Mr. Wing's special field of exploration was the part of the lime stone region and of the adjoining country lying between Rutland and Monkton. The Eolian limestone formation occupies the broa valley of "Otter Creek" (correctly Otter River), and also the of its main tributaries.

The accompanying map is from the colored chart of the V mont Geological Report. Mr. Wing's notes suggest seve changes; but only two of them have been made, because information is not sufficiently precise to warrant going furthe these are, the elongation of the "central belt of slate" to midd Weybridge, and the closing of the West Rutland limestone on the north by a junction of the area of slate on the east with

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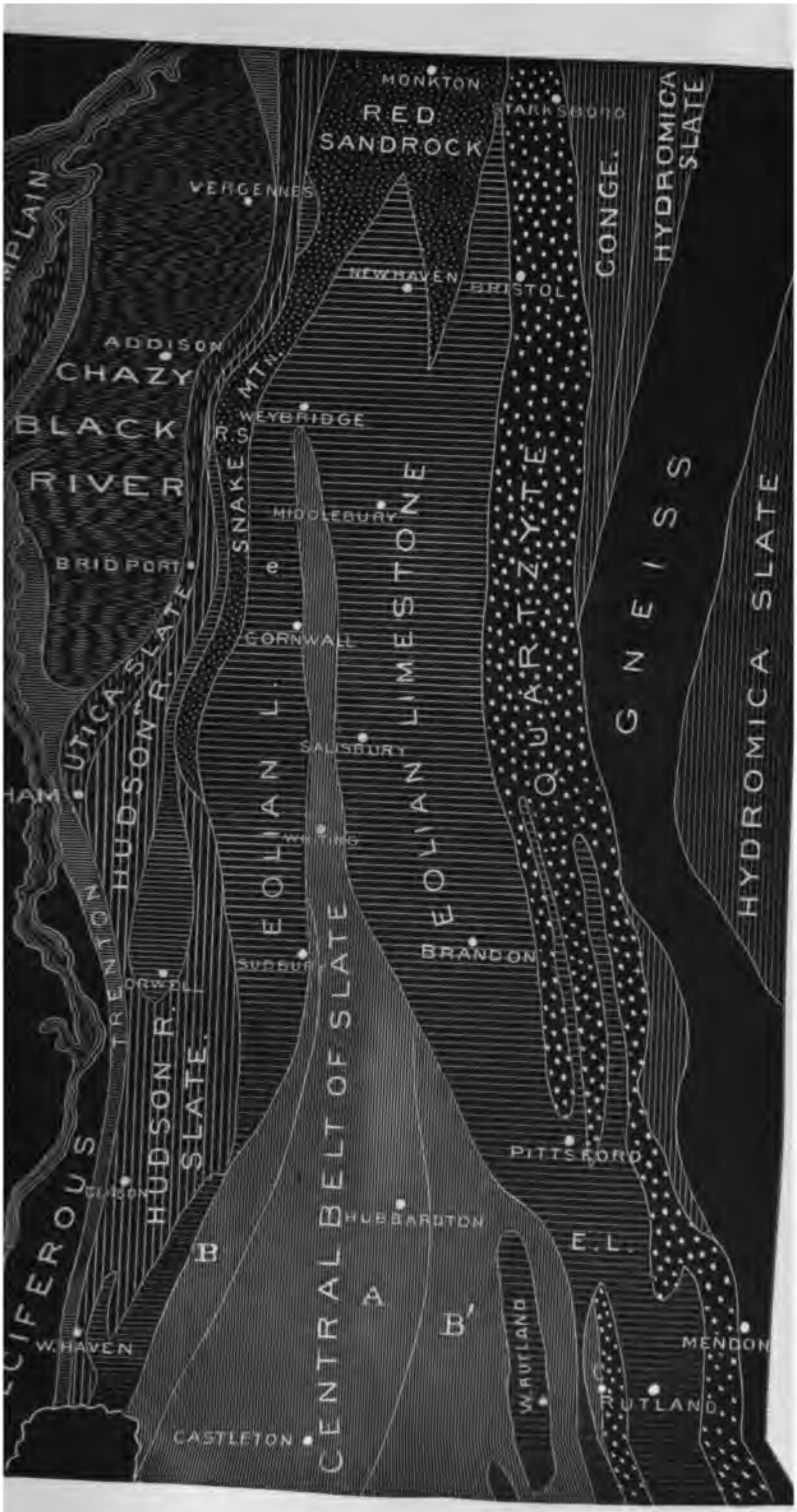
[*] Report on the Geology of Vermont, by Edward Hitchcock, LL.D., Edw Hitchcock, Jr., M.D., Albert D. Hager, A.M., and Charles H. Hitchcock, A.M. T vols. 4to, 1861. Published by the authority of the State Legislature.

[†] The hydro-mica slates include the "Talcoid schist" and "Talcose schist" the Vermont Geological Report, the fact that they are not talc-bearing or sian being one of the results of the survey. Mr. Wing uses the term "Talc schists" in his earlier notes, but adopts hydro-mica slates in the later; and *therefore* make the substitution whenever the rock is referred to.


MONKTON
RED SANDROCK
STARKSBORO
CONGE.
HYDROMICA SLATE
VERGENNES
MPLAIN
NEWHAVEN
BRISTOL
ADDISON
CHAZY
BLACK RIVER
R.S.
SNAKE MTN.
WEYBRIDGE
MIDDLEBURY
EOLIAN LIMESTONE
QUARTZYTE
GNEISS
HYDROMICA SLATE
BRIDPORT
e
UTICA SLATE
HUDSON R.
CORNWALL
EOLIAN L.
SALISBURY
HAM
WHITING
TRENTON
HUDSON
BRANDON
SUDBURY
ORWELL
HUDSON R. SLATE.
CENTRAL BELT OF SLATE
CIFEROUS
PITTSFORD
GIBSON
HUDSON
HUBBARDTON
B
E.L.
A
B′
W.HAVEN
W.RUTLAND
C
RUTLAND
MENDON
CASTLETON

"great central slate belt," that limestone, according to Mr. Wing, not extending to the pond in Pittsford. Besides these, the long Tertiary area, following the eastern border of the main mass of Eolian limestone has been omitted, since it was based on a few local limonite deposits, which were mainly a result of the alteration of either the limestone, or of the slates adjoining associated with the quartzyte, or perhaps partly of the quartzyte itself where impure, and which were forming during earlier as well as later time.

On the map all the areas that are horizontally lined are limestone areas; those vertically lined are slates (hydromica or argillaceous); the dotted area on the east is quartzyte, and the finely dotted on the west and north, Red Sand-rock. The areas most openly lined horizontally are those of the "Eolian limestone," the crystalline or metamorphic limestone, which includes nearly all the marbles of Vermont south of Monkton.

The main or eastern band of the Eolian limestone follows the course of Otter Creek valley, and, no doubt, determined the position of the valley. There is also, north of West Haven, a western band, more or less complete, lying to the west of the "central belt of slate." This great slate-belt extends from Weybridge on the north to the southwestern corner of the State, widening southward and spreading into the State of New York. The part south of Brandon has been called the Taconic range of mountains, it being properly a continuation of the Taconic range of Massachusetts. This belt of slate, over its interior, consists mostly of clay-slate or argillyte (good roofing-slate in many places) (A); but, along either border (B) there is a broad band of hydromica slate, south of Whiting village, this belt is interrupted for a fourth of a mile or so, according to Mr. Wing, and here the limestone to the west of it connects with that to the east in Otter Creek valley. The geological formations on the western border of Vermont, including the Hudson River and Utica shales, with some limestone in the former, the Trenton, Black River, Birdseye and Chazy limestones, are mostly unaltered fossiliferous rocks, and hence their age was long since ascertained. The limestone areas within that of the Hudson River slate are set down as Hudson River limestone in the Vermont map; but Mr. Wing's notes imply that he thought them in part at least Trenton, yet without any special discussion of the subject.

To the east of the eastern quartzyte range there is, east of Bristol, what the Vermont map calls "talcose conglomerate," and next east of this, an area of "talcose schist," the former certainly belonging with the quartzyte, and the latter a hydromica slate, according to evidence in the Vermont Report. Farther east, ranging from the southern boundary of the State, and much of the way adjoining the quartzyte on the east side, there is on the map a broad area of gneiss, often called Green Mountain gneiss. But it is not all gneiss; for the Vermont Report states that Mount Mansfield, the highest mountain of the Green Mountain range, consists partly of chloritic hydromica slate, and this I have ound to be true. The true Red Sand-rock, existing more especially in the northern half of Vermont, toward Lake Champlain, has been shown through its fossils, since the Vermont Report was published, to be Primordial. And, by recent discoveries also, it has been proved that the Primordial of Northern Vermont includes an extensive formation of clay-slate—the Georgia slates—and a red or reddish mottled limestone, extending from Canada southward to Burlington, and in some parts fossiliferous, called the Winooski limestone. These facts need to be kept in mind when studying the metamorphic rocks of Central and Southern Vermont and Mr. Wing's views about them.

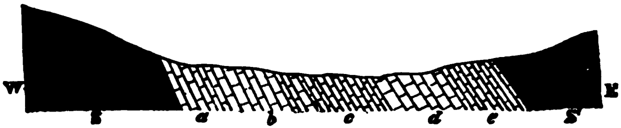
2. *West Rutland Valley.*

The West Rutland limestone valley, famous for its marble quarries, is situated four and a half miles to the west of the city of Rutland. It is separated from the wider limestone band of central Vermont, in which the city of Rutland is situated, by three north-and-south ranges of rock; the first, going west, occurring at Rutland Center (C on map), consists, at the Falls, of quartzyte and an underlying black glossy argillyte, dipping to the southeastward 10° to 20°; the second, is a narrow north-and-south strip of crystalline limestone; the third a narrow north-and-south ridge of black slate, closely resembling that at Rutland Center, and like it in the general direction of its dip, though varying much in the amount of dip and in the strike. This last ridge of black slate makes the eastern boundary of the West Rutland limestone valley, while the slopes of the "great central belt of slate" constitute the western boundary. The rock of these latter slopes is a greenish hydro-mica slate somewhat chloritic.

The limestone of West Rutland valley has a width across of about a mile. It has throughout a high eastward dip—varying between 40° and 70°; and the slates on the west, as well as those on the east, have a corresponding eastward dip. According to Mr. Wing, this band of limestone does not connect on the north with the great central limestone area of Vermont, as the map of the Vermont Geological Report and also Plate VIII represent, but runs out in that direction before reaching the pond in southern Pittsford, through the union of the slate area of the east with the area on the west.

As first discovered by Mr. Wing, this band of limestone contains fossils on both its eastern and western borders, and also along its center. The marble quarries are situated on bands of highly crystalline white and clouded limestone between the fossiliferous borders and the center. The position is shown in the following section: S and S′ are the slates of the two sides, the west and east; *a*, *c*, *e*, the belts of grayish fossiliferous limestone, *b*, *d*, those of the marble quarries. The width of the border belts, *a* and *e*, is from 200 to 300 feet.

1.

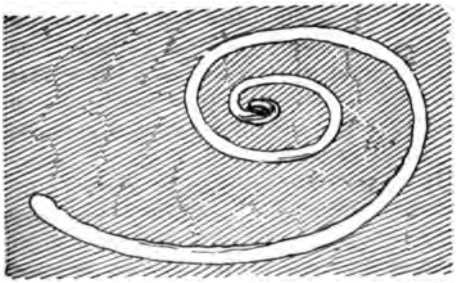


Section across the West Rutland valley.

The fossils of the western border are found in the southwestern part of the valley, just north of an old abandoned marble quarry, the most northern one on the west side of the valley, where the rock is grayer than that of the center belt. The rock here is distinctly and abundantly fossiliferous. It was from this place, at a point rather nearer the quarries than the slate, that the specimens were obtained by Mr. Wing which he sent to Mr. Billings, for his examination. Among them, "a small convoluted shell was in crowded abundance," which Mr. Billings said were like *Pleurotomaria staminea*. A short distance north, crinoidal disks and stems were common; and among these, Mr. Billings distinguished a plate of *Pleurocystites tenuiradiatus*, a Chazy species. Mr. Billings adds to his note on the fossils,* "I think this collection is Chazy. The Cystidean, *Pleurocystites tenuiradiatus*, is a never-failing guide to the Chazy; at least it is so on the west side of Lake Champlain."

On the eastern border of the valley, just east of the large marble quarries, Mr. Wing states that he "found two large convoluted shells, with a *Murchisonia* of moderate size." The limestone of this belt is gray like that of the western. The fossils are, however, much rarer.

2.



At my visit to West Rutland with Mr. Wing, we went first to the central belt, to a place south of the railroad. The rock was found to be, as he had described it, literally full of fossils. The worn surface is crowded with white spots, often having the spiral and other forms of half obliterated shells, besides disks of *Crinoids*. Some of the shells are large distorted *Maclureas*—the well-known Chazy species, and one of these, having the appearance of a white spiral line, is here figured natural size. Other similar specimens are four inches in diameter. The gray limestone of the western border of the valley was also found to be abundantly fossiliferous. That of the eastern border, just east of the marble quarries we examined, but in the short time there, no distinct fossil forms were found.

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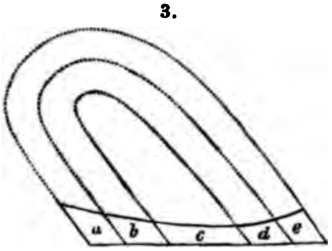
* Published in this Journal, in vol. iv, p. 133, 1872.

Mr. Wing in his notes explains the position of the Chazy belts in the limestone, and that of the slates either side by the view that the slates lie in synclinals and the limestone in an abraded anticlinal, as illustrated in the annexed figure, making the slates younger than the Chazy. He observes that he had suspected the existence of the Trenton outside of the Chazy between the fossiliferous beds and the slates, but that he had found no evidence of it, and, moreover, the "space was too thin for the normal Trenton."

3.



If there is here but *one* anticlinal, there are two fossiliferous levels in the limestone of the valley, and all the limestone is Chazy; but if a double anticlinal exists, as is possible, though perhaps not probable, then the marble belts may belong to a stratum below the Chazy.

About three miles southwest of West Rutland, in the town of Ira, and within the "great central belt of slates" there are, according to the Vermont Geological Report (p. 432), two outcrops of limestone which afford fossils, and deserve to be called fossiliferous; the fossils found were *Encrinal disks*, and shells resembling a *Euomphalus* in form. Whether related to those of the West Rutland Valley or not cannot be made out from the facts stated.

3. *Sudbury Limestone.*

The Sudbury limestone belt is situated a little over twenty miles north-northeast of West Rutland, on the west side of the "great central belt of slate." The limestone lies between the great band of slate and another on the west, and has a width of two to three miles. The area is bounded both to the north and south by slate, the western slate belt, which leaves the great belt in Benson, joining it again twelve or fifteen miles north, the rock for two miles south of the village of Whiting being slate. Thus the area is isolated like that of West Rutland, and both may be said to be contained within the slate belt. Still, there is a break or interruption in the eastern slate belt toward Whiting, and through it the Sudbury limestone connects directly, or is continuous, with that of Otter Creek valley.

In the Sudbury valley, 1½ miles south of the village, on the land of Mr. Clark Morton, the Trenton trilobite, *Trinucleus concentricus*, was first found in May, 1866, in the blocks of a stone wall which the owner said had been quarried near by; and, Mr. Wing says: "I walked home that night—seven miles—after sundown, glorying in my discovery of a Trenton fossil in Sir William Logan's Quebec Group. I was, however, dampened in all this on reading, after reaching home, in Professor Hitchcock's Report, that the *Trinucleus* had been previously found in a bowlder in Sudbury; for I could not tell whether mine came from a bowlder or not."* But "afterward, in May, 1867, I discovered the Trenton trilobite near the same spot, and in great abundance." It was associated with various other Trenton fossils, twenty or more species of which were later collected by Mr. Billings.

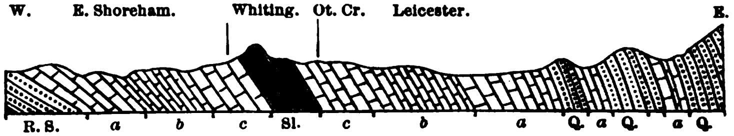
The limestone, like that of West Rutland, and the slates adjoining, all dip eastward. The limestone accordingly, says Mr. Wing, constitutes an anticlinal between two synclinals of slate—those of the slate belts or ridges.

Mr. Wing also states that he afterward found the *Trinucleus concentricus* ten miles southeast of Sudbury (half way to West Rutland) in Hubbardton, in a limestone band sixty yards wide in the heart of the "great central belt of slates;" and also farther south, one or two miles north of the slate-quarries of West Castleton.

4. *Eastern Orwell and Shoreham, Whiting and Cornwall.*

The towns directly north of Sudbury are Whiting and Cornwall, and those adjoining these on the west, Orwell and Shoreham. The area of Eolian limestone—that of its west branch—covers only the eastern half of Orwell and Shoreham, the "great slate belt" occupying the western half. But this slate belt passes northward through the middle of Whiting and Cornwall, so that the western part of each of these towns is

Fig. 4.



Section from the Red sand-rock in Eastern Shoreham to the Quartzyte rocks and interstratified Dolomite of Eastern Leicester, east of the main belt of Eolian limestone.

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* The Vermont Report says (p. 301) only this: "A bowlder of this rock [Trenton limestone] has been found in Sudbury, containing this species, which must have been transported several miles,"—a statement which implies no suspicion of its being a Sudbury fossil.

covered with the western branch of the Eolian limestone, and the eastern with the eastern or Otter Creek branch.

The preceding section is given by Mr. Wing to show the succession of formations across the whole limestone region, from the Red Sand-rock in Eastern Shoreham, to the quartzyte region of Eastern Leicester, a distance of twelve or fourteen miles. It shows the eastward dip throughout; the narrow strip of slate to the west of the middle; and three sections of the Eolian limestone east and west of this slate: *a*, Lower Calciferous; *b*, Upper Calciferous and Quebec; *c*, Chazy and Trenton; R. S., Red Sand-rock; Sl., slates; Q, quartzyte. How far this conclusion is based on positive facts will be seen beyond.

On the *east* side of the slate in East Cornwall various fossils were found in the limestone. These were sent to Mr. Billings, who replied as follows: "The specimens from East Cornwall east of Dr. Porter's residence, and from a locality farther north, are *Stenopora fibrosa*, *St. Petropolitana*, *Escharopora recta?*, part of the rim of a *Trinucleus* or *Harpes*, and species of *Orthis*, *Strophomena*, *Rhynchonella* and *Orthoceras*;" and he added that "they are no doubt Trenton."

North and south of East Cornwall, there are "*Rhynchonella* beds" full of fossils, including pygidia of *trilobites*, a large *Maclurea*, species of *Orthis*, *Encrinal disks*, and other kinds; and, half a mile south, one undoubted *Bathyurus Saffordi*, a Quebec Group trilobite, was obtained.

Near the west border of Cornwall, at *Bascom's ledge* (three miles west of south of West Cornwall and three and one-half miles east of Shoreham), a bed in the "Eolian limestone" is called by Mr. Wing the "Trilobite bed," it being almost made up of remains of trilobites, with other fossils. It afforded—as identified in 1867 by Mr. Billings from specimens sent him by Mr. Wing—*Asaphus canalis*, besides two other species of the genus, two or three species of *Bathyurus*, one of them *B. conicus*, some of the cephalic spines of this species, three, four, and, four and one-half inches long, besides *Maclurea matutina* and other convoluted shells. Mr. Billings made the species Calciferous.

East of Shoreham village the upper limestones hold *Bathyurus extans* Billings (*Asaphus? extans* Hall), a Birdseye species, *Columnaria alveolata*, of the Black River limestone, and the Trenton trilobite, *Trinucleus concentricus*.

Barbour's Ledge, in southern Bridport, near Mr. J. Barbour's residence, affords similar fossils to Bascom's Ledge, including many pygidia of trilobites of the species *Asaphus canalis*, and *Bathyuri*, and also, in an overlying bed, *Maclurea matutina* and other convoluted shells and trilobites.

The "Rhynchonella beds" extend from West Cornwall to a mile or two south of Orwell, fifteen to eighteen miles. But in

Orwell, in higher limestones immediately west of and underlying the "sparry limestone," there occur *Petraia profunda* (?), *Stenopora fibrosa* and *St. Petropolitana*, "which may be Birdseye species;" and at the bottom of a hill one and one-half miles northeast of Orwell village, where the "sparry limestone is largely developed," a number of large *Maclureæ* were found (one, as figured in the notes, three inches in its longer diameter, and resembling fig. 2 on page 338), which seems to indicate the presence of the Chazy limestone beneath the "sparry limestone," or at its base. Higher up toward the top, there are obscure fossils; but at the top, near the slate, occur distinct bivalves, and the coral *Receptaculites Neptuni*, which seems to prove the "Sparry limestone" to be Trenton in age.

In northeastern Shoreham, two miles north of Shoreham village, there is a limestone ledge called Mutton Hill, and here several Lower Silurian formations are distinguishable by their fossils. The rocks, in the words of Mr. Wing, have the following ascending order:

1. Light gray even-bedded sandstone, in beds six inches to two or three feet thick; six or eight feet at the top, honeycombed with *Scolithus linearis:* Potsdam. 310 feet.

2. Dark iron-gray, feebly calcareous sandstone or quartzyte, with *Fucoids:* Upper Potsdam? 200 feet.

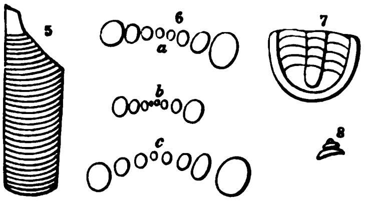
3. Subcrystalline limestone, containing a small *Orthoceras* and Encrinal disks: Lower Calciferous. 20–25 feet.

4. Dark greenish, fine-grained sandstone, the lower twelve or fifteen feet perforated with small *Scolithi* (*S. minutus*), the rest interstratified with dolomitic limestones, holding *Ophileta compacta*, *O. complanata*, (hence called the *Ophileta beds*), a few other species of convoluted shells including two or three *Maclureæ*, a small *Orthis* (*Orthisina*), a *Trilobite*, etc.: Calciferous. 300–400 feet.

No. 1 is at the western base of Mutton Hill and No. 4 is its geological top.

In a second fold or anticlinal, Nos. 1, 2, 3 and 4 again come up; and No. 3 is more than 200 feet thick and holds a number of small *Orthocerata*, two species of *Gasteropods*, including a *Maclurea* and a *Bathyurus*. The accompanying figures by Mr. Wing serve to sustain his statements. Figure 5, an *Orthoceras* apparently the Calciferous species, *O. primigenium;* 6, sections of *Maclureas;* 7, pygidium of a *Bathyurus*; 8, shell resembling a *Holopea*.

5–8.



In this "second fold," No. 4, or the "Ophileta beds," *Scolithus minutus* and the Fucoid *Palæophycus arcuatus* are abundant.

In the same fold, above No. 4, appears No. 5, called the "*Trilobite bed and Conglomerate.*" It consists below of dark bluish sandstone or quartzyte with green slaty seams containing Fucoids; then ten or fifteen feet of siliceous limestone, holding a few small *Trilobites* and other fossils; then a conglomerate made of flat and rounded pebbles from the quartzyte below—the flat ones one to two inches across, the rounded, from coarse shot to large bullets; the paste sometimes limestone; the slaty seams holding toward the bottom a small *Orthis* (*Orthisina*), a small *Trilobite*, and, near the top, *Maclurea sordida* and *M. matutina* in crowded abundance at some places. This "conglomerate may generally be traced along the west side of the great slate belt without aid from its fossils."

At Bascom's Ledge, which is the "fourth fold" going eastward from Mutton Hill, Nos. 1, 2, 3, 4 and 5 occur, with their fossils, and the lower part of No. 5, the "Trilobite" or "Conglomerate" bed exists in great force. The Trilobites (*Asaphus*, etc.), and other fossils mentioned on page 341 are from this bed, ten or twelve feet of it being made up almost entirely of them. There is also above the "conglomerate," No. 6, the "Rhynchonella beds" already mentioned—so called from "real or supposed *Rhynchonellæ* found in the next (5th) fold." This No. 6 is a nearly pure, or feebly siliceous, or dolomitic limestone, finer in grain and softer than the formations below, generally weathering to some shade of yellow, red, pink, or buff; and is without fossils in the line of section of the 4th fold.

Over No. 6 occurs No. 7, the *Sparry Limestone*, 400 to 600 feet thick; and No. 8, the slate of the great belt, here perhaps 300 or 400 feet thick. The Sparry Limestone is the stratum that, one and a half miles northeast of Orwell village, afforded the *Receptaculites Neptuni*, "which seemed to prove" its Trenton age; and is the Sudbury rock affording *Trinucleus*. The *slate* would consequently be the Hudson River slate.

The formations above recognized are, briefly, as follows:

1. Sandstone.—*Potsdam.*
2. Iron-gray calcareous sandstone.—*Upper Potsdam.*
3. "Subcrystalline limestone," part of the "Eolian Limestone" containing *Orthoceras*, etc.—*Lower Calciferous.*
4. "Ophileta beds," part of the "Eolian Limestone."—*Calciferous.*
5. "Trilobite bed" and "Conglomerate," part of the "Eolian Limestone."—*Quebec Group.*
6. "Rhynchonella beds" with the "striped stratum," part of the Eolian Limestone.—*Chazy.*

7. "Sparry Limestone," part of the "Eolian Limestone."—*Trenton.*

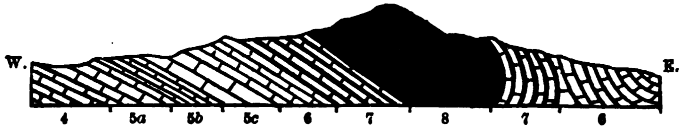
8. The slates of the "great central belt."—*Hudson River Slates* (or, Cincinnati group).

5. *Northern Cornwall, Middlebury, Weybridge.*

Weybridge is the next town north of Cornwall, and Middlebury lies to the east of Southern Weybridge and Northern Cornwall. The area of the Eolian limestone includes both towns on the Vermont Geological Map.

Ellsworth Ledge is situated in North Cornwall, two and a half miles northeast of "Bascom's Ledge," and two or three miles west of Middlebury. It is Mr. Wing's *fifth* fold. The "great central slate belt," instead of stopping in Cornwall as represented on the Vermont Geological Map, continues on, as a narrow belt, and part of the way a double belt, to middle Weybridge.

9.



Mr. Wing's section from west foot of Ellsworth Ledge, in Cornwall, to Middlebury on the east.

Commencing at the western base of Ellsworth Ledge (see the accompanying section from Mr. Wing's notes) there is no outcropping Lower or Upper Potsdam, and No. 3 also is wanting: the first formation is No. 4, the "Ophileta beds" with their fossils; next No. 5, *a*, *b*, *c*, the "Trilobite bed" and those associated; next No. 6, the "Rhynchonella beds," with fossils; then No. 7, or the "Sparry Limestone," with fossils, this and the preceding of unusual thickness; and No. 8, the Hudson River slate.

Overlying the "Conglomerate bed" (No. 5 *b*) there is a bed of coarse limestones, (5 *c*) 100 or 200 feet thick, holding obscure convoluted shells (*Maclurea ?*), a large *Orthoceras* and *Murchisonia*, and *Bathyurus Saffordi*, a species characteristic of the Quebec group.

Above this stratum come the "Rhynchonella beds," (No. 6) perhaps 300 to 400 feet thick, containing, in a "striped stratum" characteristic of it, *Rhynchonellæ* (?) in great abundance, pygidia of *Asaphus canalis* and of one or two other species of *Asaphus*, pygidia of *Bathyurus Angelini*, a Chazy species in Canada; also species of *Maclurea*, *Orthis*, *Leperditia* (a small hand specimen containing them by the thousands), *Encrinal stems*, etc. This "striped stratum," twelve to fifteen feet thick s overlaid by an inch or so of a dark slaty sandstone and then y a stratum of white limestone (weathering yellow) six to welve inches thick. These "Rhynchonella beds" are without nuch doubt Chazy in part; the upper part may be Birdseye nd Black River. Since the Birdseye and Black River do ertainly exist in Orwell and half a mile east of Shoreham illage, there is not much doubt that they exist here also.

The "Sparry limestone" does not here afford fossils. The age f the rock is inferred from the fossiliferous beds farther south n similar position in Cornwall, Sudbury, Hubbardton, the facts especting which have been already mentioned. "Trenton fossils ccur also in Benson, and on the same strike in Whitehall, ew York;" so that "it is no longer to be doubted that the Trenon limestone does exist in long bands stretching down on the est side of the two belts of slate from Weybridge southward."

At Weybridge Upper Falls, on the right bank, the "Rhynhonella beds" occur west of the slate, beneath the "Sparry imestone;" and the "striped stratum," which is partly cut hrough by the stream, is full of fossils, as first observed in 867; and the species are the same *Rhynchonellæ* and convouted shells that were found in the "Rhynchonella beds" west f the slate in Cornwall—a fact which makes the two beds entical in age. On the south side of the Falls occurs *Retepora cepta.* This makes the beds to be of the age of the Chazy, nd proves that the Chazy formation has a wide range, the eds in Cornwall affording *Asaphus canalis*, *Bathyurus Angelini*, *eperditia*, etc., as already stated. "No marble quarries in ddison county have been wrought in the Quebec Group; all re now wrought in the Chazy and formations above it, or in he sheet of limestone at the bottom of the Calciferous."

In Middlebury, the "Sparry limestone" affords "very large nd conspicuous *Encrinal stems;* they occur mostly near the late, like the few other fossils of this slate." The formation is continuation of that of East Cornwall.

The limestone bordering the "central slate belt" on the east, s the same formation with that on the west. This has been roved by the fossils, as already stated. It is also shown by he fact that this main belt of slate, which extends south from eybridge to join the wider belt of the southwestern part of e State, is wholly cut off by limestone in the north part of udbury, the cut being 40 or 50 rods wide, as stated on page 39. "The limestone at the break is certainly not lower than e Chazy and Trenton, and it is continuous with the fossilifeous Trenton limestone of Sudbury on one side, and with that f Otter Creek valley on the other; and hence the limestones n the east of the slate, in Otter Creek valley, must be of the ame age as those on the west."

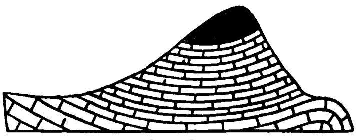
Moreover, other facts give us the age of the slates. "For the limestones at the northern terminus of the slate seem to dip down around *under* the slate. The limestones on the west dip eastward beneath the slate, and so do the slates and limestone beds on the east, the slate being an inverted synclinal and the limestones abraded anticlinals. Indeed, one of the folds of the slate shows the limestone continuing around under the synclinal axis of the slate." "The evidence is plain that the slates are decidedly the more recent." Moreover, thin beds of limestone in the slate actually contain Trenton fossils (p. 339).

The fact that the slates overlie the limestone, and are therefore Hudson River slates, is further shown in the direct and nearly horizontal superposition of the latter by the former in several high summits south of Rutland, as in Mount Dorset or Eolus in the town of Dorset; Danby Mountain, on the borders of Danby and Dorset, just north of Eolus; Equinox Mountain, in the town of Manchester, the town next south of Dorset; in Spruce Peak, in Arlington, to the southwest; in Mount Anthony, in Bennington, farther south; and in Graylock, in northern Berkshire, in Massachusetts.

The Vermont Geological Report mentions, on the authority of determinations by Professor Hall, the occurrence in the Eolian limestone of a species of *Euomphalus* in Sudbury and also in Whiting; of a *Zaphrentis* in Sudbury, and also in Cornwall, along with species of *Euomphalus* and *Chætetes*; of *Stromatopora* in Sudbury, Orwell and Cornwall, and in East Middlebury, Brandon, New Haven and Williston; of large *Encrinal stems* in Sudbury and Cornwall; of a species of *Stictopora* "remarkably well defined" in Sudbury.

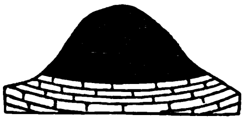
The Vermont Report gives also the particulars with regard to the stratification in the above mentioned mountains, with sectional views of some of them, which are here reproduced. Mount Eolus (fig. 10), 3,148 feet above the sea-level, has a cap of hydromica slate, about 500 feet thick (498 feet, Vt. Rep., p. 412), overlying in a very shallow synclinal 1,960 feet of Eolian limestone.

10.



Mt. Eolus, Dorset.

11.

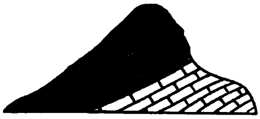


Spruce Peak, Arlington.

Danby Mountain is a continuation northward of the same mountain, with the same structural conditions, but with the slate, "according to a rough trigonometrical calculation" (Vt. Rep., p. 433), 1,354 feet thick. In Mt. Equinox, which is 3,872 feet in height, according to Guyot, the limestone rises "as high perhaps as in Mt. Eolus." In Spruce Peak, Arlington (fig. 11), the slates,

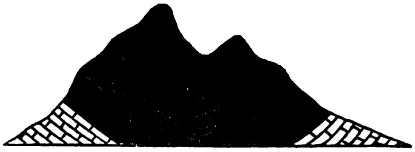
almost horizontal but in a shallow synclinal, constitute the larger part of the height, and overlie about 300 feet of limestone. In the Bennington Mountain, Mt. Anthony (fig. 12), 2,688 feet high, the Eolian limestone makes the base, and over it are about "1,800 feet of shales and schists," dipping westward on the east side, and slightly eastward on the west side. In Graylock (fig. 13), having a height of 3,505 feet, the structure is like that of the mountains just described. The section of the mountain here given, copied from the Vermont Report, is that published by Prof. Emmons. My own observations in the region, undertaken under the idea that Prof. Emmons's view was wrong, ended in proving him right. Over 2,000 feet of slates overlie the limestone.

12.



Mt. Anthony, Bennington.

13.



Graylock.

Again, the occurrence of isolated north-and-south belts or ledges of limestone within the "great central slate belt"—as for example, those of West Rutland, Ira, Castleton, Hubbardton, Sudbury—suggests, first, that the slate where broadest is not one synclinal, but one with several subordinate anticlinals and synclinals; and, secondly, that the limestone was brought up to the surface from beneath by means of the anticlinals.

It remains to give an account of the fossils and stratification of the limestone and quartzyte of North Middlebury and New Haven; of the eastern belt of quartzyte and the bordering limestone; and of the great fault at Snake Mountain, west of Middlebury; and to present the general conclusion deduced by Mr. Wing from his observations.

(To be continued.)

ART. XXXIX.—*Notes on the History of Helianthus tuberosus, the so-called Jerusalem Artichoke;* by J. HAMMOND TRUMBULL and ASA GRAY.

UNDER this heading the Botanical Editor of the Journal proposes to offer a few explanatory remarks, introductory to the subjoined letter which he received from Mr. Trumbull in answer to a recent enquiry.

Linnæus, in the Species Plantarum, gave to *Helianthus tuberosus* the "habitat in Brasilia." In his earlier *Hortus Cliffortianus* the habitat assigned was "Canada." M. Alphonse

DeCandolle, in his *Géographie Botanique*, ii, 824, (1855), refers to this as "decidedly an error, at least as to Canada properly so called," assigns good reasons for the opinion that it did not come from Brazil, nor from Peru (to which the name under which it appeared in cultivation in the Farnèse garden seemed to refer), but in all probability from Mexico or the United States. He adds that Humboldt did not meet with it in any of the Spanish colonies.

About this time I received from my friend and correspondent, the late Dr. Short of Kentucky, some long and narrow tubers of *Helianthus doronicoides* Lam., with the statement that he and some of his neighbors found them good food for hogs, and, if I rightly remember, had planted them for that purpose. They were planted here in the Botanic Garden; after two or three years it was found that some of the tubers produced were thicker and shorter; some of these were cooked along with Jerusalem artichokes, and found to resemble them in flavor, although coarser. Consequently, in the second edition of my *Manual of the Botany of the Northern United States* (1856), it is stated that *H. doronicoides* is most probably the original of *H. tuberosus.* This opinion was strengthened year after year by the behavior of the tubers, and by the close similarity of the herbage and flowers of the two plants, as they grew side by side; indeed, as the two patches were allowed to run together in a waste or neglected place, they have become in a measure confounded. Wishing to obtain an unmixed stock, I applied last autumn to Prof. J. M. Coulter of Hanover, Indiana, and received from him a good number of tubers from wild plants of the neighborhood, which will now be grown. Some of these were slender, some thicker and shorter, and a few were to all appearance identical with Jerusalem artichokes. If they were really all from one stock, as there is reason to believe, the question of the origin of *Helianthus tuberosus* is well nigh settled.

We were now interested to know whether our Indians—at least those of the Mississippi Valley, where *H. doronicoides* belongs,—were known to cultivate these tubers or to use them for food. Recently a note in the American Agriculturist called attention to a sentence in Dr. Palfrey's History of New England, i, 27, stating that the Indians of that region raised, among other articles of food, "a species of sunflower, whose esculent tuberous root resembled the artichoke in taste." The venerable historian found himself at the moment unable to refer me to the sources of this statement; but, as it was now certain that some record of the kind existed, I applied to Mr. Trumbull, who obligingly and promptly supplied the information required, and placed it at my disposal in the following letter:—

HARTFORD, CONN.; March 26, 1877.

My dear Prof. Gray:—I cannot refer you to the authority (*totidem verbis*) for Dr. Palfrey's statement that the Indians of New England cultivated "a species of sunflower whose esculent tuberous root resembled the artichoke in taste," but there can be, I think, little doubt of the *fact.* The historical evidence that "artischoki sub terrâ" were cultivated in Canada and in some parts of New England before the coming of Europeans is tolerably clear. The only question, if there be any, is as to *species*, and this does not appear to have been raised for more than half a century after the "Jerusalem artichoke" was known to English and Continental botanists.

I can discover no authority whatever, before 1700, for ascribing to the *Helianthus tuberosus*, either a Brazilian or a Mexican origin, except—and the exception is unimportant—in C. Bauhin's identification (in his *Pinax*, 277) with "Helianthemum Indicum tuberosum" (H. tuberosus, L.), of a plant that he had described in his earlier *Prodromus* (ed. 1671, p. 70) as "Chrysanthemon latifolium *Brasilianum*," from a dried specimen sent to him "eo nomine" from the garden of Contarini.

The first trace I find of this species, in Europe, is in the 2d part (cap. 6) of Fabio Colonna's "Ecphrasis minus cognitarum stirpium," published at Rome in 1616. He described it from a plant growing in the garden of Cardinal Farnese. The sunflower was already well known to European botanists, and had been described and figured by Dodoens (1563) and Lobel (1576) as "Chrysanthemum *Peruvianum*" and "Flos solis *Peruvianus*." With reference to these descriptions, probably, Colonna gave the new species the name of "Aster *Peruanus*, tuberosâ radice," otherwise "Solis flos Farnesianus." (He gave a more particular description of the plant in his annotations to Recchi's Hernandez, Plant. Mexic. Hist., 1651, pp. 878, 881, as "Peruanus Solis flos ex Indiis tuberosus.")

The author of the "Descriptio variorum plantarum, in Horto Farnesiano," published under the name of Tobias Aldinus (Rome, 1625), gave some account of the *roots*, which he calls "Tubera Indica," of the "Solis Flos tuberosus, seu Flos Farnesianus Fabii Columnæ" (p. 91). It may be observed, that several of the rarer plants in the Farnese garden, at this time, were from "Canada" and "Virginia." The Passion Flower (admirably figured by Aldinus) is described under its *Virginian* name, "Maracot" (the "Maracocks" of John Smith and Strachey); and a "Campanula Americana" is otherwise named "Campanula Virginiana, seu ex Virginiis insulis."

C. Bauhin, in his Pinax (first published in 1623), ed. 1671, p. 276, notes that the "Helianthemum Indicum tuberosum" is called "Chrysanthemum è *Canada*, quibusdam. *Canada* et *Artischoki sub terrâ*, aliis. *Gigantea*, Burgundis."

P. Laurenberg, *Apparat. plant.* (Rostock, 1632), names the species, "Adenes *Canadenses* or Flos Solis glandulosus." Ant. Vallot, *Hortus Regis Paris.*, 1665 (as cited by Bauhin) gives the names "*Canada* and *Artischoki* sub terrâ," and "*Canadas*," and describes, also, "Helenium Canadense altissimum, *Vosacan* dictum," which Tournefort distinguishes as "Corona Solis *rapunculi radice*" (Inst. Herb. 490), and which became *H. strumosus* L. "Vosacan," by the way, is a French fashion of writing the Algonkin word *wassakone* or *wassakwân*, which means a 'bright yellow flower.' The modern Chippeways give this name to the flowers of the pumpkin and squash.

Under whatever name the Jerusalem Artichoke was described, there seems to have been a general agreement among European botanists that it came from Canada. F. Schuyl, *Catal. Horti Lugd.* Bat. (Heidelberg, 1672), varies the specific name to "Chrysanthemum *Canadense Arumosum*." P. Amman, *Charac. Plant. Nat.* (1676), has "Helenium Canadense."

It was introduced to England about 1617. In that year, Mr. John Goodyer, of Maple Durham, Hampshire, "received two small roots thereof, from Mr. Franquevill of London," which were planted, and enabled him, before 1621, to "store Hampshire." He wrote an account of the plant, under date of October 17, 1621, for T. Johnson,—who printed it in his edition of Gerard, 1636 (p. 753). Before this the species had been figured and described by J. Parkinson, in *Paradisus Terrestris* (London, 1629), as "Battatas de *Canada*," and in his *Theater of Plants*, 1640 (p. 1383), he has the figure—a good one—without the description, under the names "Battatas de Canada, the French Battatas, or Hierusalem Artichoke." Johnson, in Gerard (p. 753), refers to Parkinson's description, and gives the name as "Flos Solis Pyramidalis, Jerusalem Artichoke." It already grew "well and plentifully in many parts of England."

The notices by early voyagers, of ground-nuts, eaten by the Indians, are generally so brief and so vague, that it is not easy to distinguish the three or four species mentioned under that name or its equivalents. The *Solanum tuberosum*, *Apios tuberosa*, *Aralia trifolia*, and a *Cyperus* (*articulatus ?*) were all "ground nuts," or "earth nuts." We find, however, in a few instances, unmistakable mention of the roots already known in Europe as "Canadian."

Brereton, in his account of Gosnold's voyage to New England in 1602, notes the "great store of ground nuts" found on all the Elizabeth Islands. They grow "forty together on a string, some of them as big as a hen's egg" (Purchas, iv, 1651). These, doubtless, were the roots of *Apios tuberosa*. But when Champlain, a few years later (1605–6) was in the same region, he observed that the "Almouchiquois" Indians near Point

Mallebarre (Nauset harbor, probably,) had "force des racines *qu'els cultivent*, lesquelles *ont le goût d'artichaut*" (Voyages, ed. 1632, p. 84). And it is to these roots, evidently, that Lescarbot alludes, *Histoire de la Nouv. France*, 1612 (p. 840): there is, he says, in the country of the Armouchiquois (i. e., New England, west and south of Maine,) a certain kind of roots "*grosses comme naveaux*, très excellentes à manger, ayans *un goût retirant aux cardes*, mais plus agréable, *lesquelles plantées multiplient* en telle façon que c'est merveille;" and he thinks these must be the "Afrodilles" described by Pliny.

Sagard-Theodat (*Hist. du Canada*, 1636, p. 785) mentions the cultivation of the sunflower, by the Hurons—who extracted oil from its seeds,—and names also the "roots that we [the French] call *Canadiennes* or *Pommes de Canada*, and that the Hurons call *Orasqueinta*, which are not very (assez peu) common in their country. They eat them raw, as well as cooked, as they eat another sort of root resembling parsnips [Sium lineare?], which they call *Sondhratates*, and which are much better; but they seldom gave us these, and only when they received some present from us or when we visited them in their cabins." He goes on to speak of "patates, fort grosses et très-excellentes," some of which he had obtained from an English vessel captured by the French; but none of these were to be found in the Huron country, nor could the Indians tell him the name of them; and he regretted that he had not brought some with him, for planting, since "this root, being cut in pieces and planted, quickly grows and multiplies, it is said, *like the pommes de Canada*" (pp. 781, 782). It is plain that the Huron roots first-mentioned were, or that Sagard believed them to be, 'Jerusalem Artichokes,'—already known as "Canadian."

I find no mention of the artichoke in Virginia, or the southern colonies, before it was cultivated by Anglo-Americans. The author of "A Perfect Description of Virginia," printed in 1649, says that the English planters have (inter alia) "roots of several kindes, Potatoes, Sparagus, Carrets, ... and Hartichokes." Beverly, (Hist. of Virginia, 1722, p. 254), mentions "Batatas Canadensis, or Jerusalem Artichoke," as planted by some of the English, for brewing beer. Yet, the *name* of one of the esculent roots mentioned by Hariot (Brief and True Report, etc., 1585) *ought* to belong to some species of 'Sun Flower'—and if to any, to *H. tuberosus*. Hariot names three tuberous roots found in Virginia: "*Openauk*, a kind of roots of round form, some of the bignes of walnuts, some far greater, which are found in moist and marish grounds growing many together one by another in ropes, or as though they were fastened with a string. Being boiled or sodden, they are very good meate." [C. Bauhin (Prodromus, 89) identifies these with "Solanum tuberosum esculentum,"—and has been followed by later writers. The description seems to me to indicate *Apios tuberosa.*] "*Kaishucpenauk*, a white kind of roots about the bignes of hen egs and nere of that forme: their taste was not so good to our seeming as of the other, and therefore their place and manner of growing not so much cared for by vs: the inhabitants notwithstanding vsed to boile and eat many." These *may* be 'Virginia potatoes,' but their *name*, if Hariot recorded it correctly, means '*Sun*-tubers.' The etymology is perfectly clear. The other roots described by Hariot, "*Okeepenauk* are also of round shape, found in dry grounds: some are of the bignes of a man's head," etc. These must be the "Tubera terræ maxima," of Clayton, "vulgo *Tuckahoo*," which Gronovius (Fl. Virgin., 205) refers to *Lycoperdon solidum* L, and for which Rafinesque (Med. Fl. ii, 270) proposed a new genus "Tucahus." Kalm describes them (Travels, i, 225) as "Truffles." Fries (El. Fung. ii, 39) assigns them to his *Pachyma cocos.*

Writing in haste and with frequent interruptions, it has been possible to do little more than copy, without condensing or arranging, such notes as I had before me. They have extended to such a length that I must not add even an apology for the superfluous matter.

Yours truly,
J. H. TRUMBULL.

It would be interesting to know whence came the French name of these Helianthus tubers, "Topinambour," it being the only thing in the case which, as Mr. Trumbull remarks, "looks to a Brazilian origin, as it seems to be derived (and so Littré gives it) from the Topinamboux Indians of Brazil." The English name, "Jerusalem Artichoke," comes, as is well known, from the Italian *Girasola*, i. e., sun-flower.

As to the annual sunflower, or *Helianthus annuus*, said by Linnæus to come from "Peru" and "Mexico," I have for some years been convinced that its original is the *H. lenticularis* of Douglas, which again is probably only a larger form of *H. petiolaris* of Nuttall, natives of the western part of the Mississippi Valley and of the plains to and beyond the Rocky Mountains. It is an interesting confirmation of this opinion, that Sagard (as-mentioned in the above communication) and Champlain found this sunflower in cultivation by the Huron Indians, for the sake of the oil of its seeds, which they used for hair-oil.

ART. XL.—*A new Investigation of one of the Laws of Friction;* by A. S. KIMBALL, Professor of Physics in the Worcester Institute of Industrial Science.

REULEAUX, in the appendix to his recently published "Cinematics of Machinery," says that "many engineering schemes have failed because they were designed in accordance with the statements given in our text-books as the laws of friction." He furthermore adds, "that it is time that the experiments of Bochet and Hirn should be raised from their place as foot-notes to a position in the text."

During the last year, I have conducted experiments, on as extensive a scale as our laboratory would allow, for the purpose of settling, if possible, certain contested points in the doctrine of friction.

Our manuals of mechanics, following Morin and Coulomb, say the coefficient of friction *does not vary with the velocity.* Bochet says that it *decreases as the velocity increases.* Hirn says that it *increases as the velocity increases.* Contradictory as these statements are, it is probable that each contains a partial truth. They need to be combined to make a complete statement.

The results of my experiments, which this paper is to describe, would indicate that the following is the true law, within the range of my experience. The coefficient of friction at very low velocities is small; it increases rapidly at first, then more gradually as the velocity increases, until at a certain rate, which depends upon the nature of the surfaces in contact and the intensity of the pressure, a maximum coefficient is reached. As the velocity continues to increase beyond this point, the coefficient decreases. An increase in the intensity of the pressure (the number of pounds on a square inch), changes the position of the maximum coefficient, and makes it correspond to a smaller velocity. The more yielding the materials between which the friction occurs, the higher is the velocity at which the maximum coefficient is found. Heating the rubbing bodies changes the position of the maximum coefficient to a higher velocity, since by heat the bodies are made softer, and are caused to yield to pressure with greater ease. For a considerable range of velocities in the vicinity of the maximum coefficient the coefficient is sensibly constant.

The experiments upon which I base my conclusions may be classified as follows:

(1.) Sliding friction down an inclined plane.
(2.) Sliding friction at uniform velocities on a horizontal plane.
(3.) Friction of belts on the surface of cast iron pulleys.

(4.) Friction of wrought iron journals in boxes or bearings of different materials.

(1.) *Sliding friction down an inclined plane.*—A full description of the apparatus used, and some of the results obtained, will be found in this Journal, March, 1876; also in Van Nostrand's Eclectic Engineering Journal, June, 1876. It is sufficient for my purpose to say that the sliding body was made to carry a smoked glass, upon which was traced a waved line, which by direct measurement gave the time of sliding and the spaces passed over, from which it was easy to compute the corresponding coefficients of friction. In the article referred to, no velocities less than two feet a minute were examined. An extension of the same experiment, to the case of much lower velocities, showed a curve concave toward the time line, indicating that at these velocities the coefficient of friction was increasing. As the velocities increased, the line changed its direction and became convex toward the time line; thus giving in the limits of one experiment a verification of the statements made above. For further particulars respecting this method of experiment, I refer to the article published in March of last year.

(2.) *Sliding friction at uniform velocities on a horizontal plane.* —A heavy pine plank, fifteen feet long, whose surface had been planed, was carefully leveled on the floor of the laboratory. The weight-box was mounted upon shoes which could be covered with the material experimented upon. To its forward end a spring dynamometer was attached, which was pulled by a cord wound around a drum, which was made to revolve at a constant velocity. The motive power was a fifteen horse-power Corliss engine, belonging to our machine shop, whose fly-wheel runs with great regularity at the rate of sixty revolutions a minute. A shaft from the shop runs underground to the cellar beneath my laboratory, whence through several countershafts the power is transmitted to any part of the room. By means of change pulleys, I can easily command a great range of velocities.

The experiments were made by drawing the box along the plane at various velocities, and reading the friction from the dynamometer. This combination answers very well for low velocities, but the slide can not be easily stopped when the speed is great.

Several series of experiments were made, with wood on wood, also with leather on wood. The results verify the first part of my statement, that the coefficient of friction increases with the velocity, when this is small. The following are some of the results obtained by this method of experiment.

TABLE I.—*Pine on pine. Slide loaded with* 100 *lbs. Velocity in inches in a minute.*

V.	Coefficient of Friction.
5	·19
11	·20¾
75	·24
300	·25

TABLE II.—*Leather on pine. Slide loaded with* 100 *lbs. Velocity in inches in a minute.*

V.	Coefficient of Friction.
·79	·22
1·58	·27
3·94	·33
9·98	·36
29·14	·38
72·50	·41
157·50	·43
226·80	·45
300·	·46
466·	·47½

These experiments show the increase of friction with the velocity at low speeds quite clearly; and in connection with the series published last March, which showed its decrease at high velocities, would prove the high probability of the law as I have stated it, especially since the experiment on the inclined plane has been made to show a variation of the coefficient from a low value, through a maximum, to a low value again, while the velocity constantly increases.

(3.) *Friction of belts on the surface of cast iron pulleys.*—A piece of leather belting was hung over a cast iron pulley. To one end a determined tension was given by a fixed weight; to the other end was attached a spring dynamometer. The tension of the ends of the belt being known, the coefficient of friction was easily found. Several pulleys were used, and various kinds of belting; and a considerable range of tensions was employed, with uniform results.

Two tables are here given, one selected to show the increase of the coefficient at low speeds, the other to show the existence of a maximum coefficient at a definite velocity. In the third table, the first column gives the velocity in feet in a minute; the second and third give the tensions of the ends of the belt; and the fourth gives the relative values of the coefficients found, the maximum in each case being represented by 1·00. I give relative values, since they show variations more clearly than the absolute values.

TABLE III.

V.	T_2.	T_1.	C.
·37	30	13	·42
·52	30	12½	·44
1·1	30	11½	·48
2·3	30	10½	·53
2·9	30	10	·55
4·4	30	9½	·58
15·4	30	6½	·78
34·1	30	5½	·86
80·3	30	4½	·96
104·5	30	4¼	·99
228·8	30	4¼—	1·00

In the following table only velocities and relative coefficients are given.

TABLE IV.

V.	C.
18	·82
92	·93
660	1·00
1190	·96
1980	·82
2969	·69

(4.) *Friction of wrought iron journals in boxes of different materials.*—In this course of experiments a modification of the friction brake was used. A description of the arrangement in one series will serve for all the others. A shaft 1″ in diameter was adjusted so that it could be driven at almost any rate between one revolution in two days and 1,000 in a minute. A hole was bored through a block of cast iron 3½″×3½″×1½″, and carefully fitted to the shaft; rigid iron rods were screwed into the top and bottom of this block, and adjusted to stand in a vertical line at right angles to the shaft. Upon these rods slotted weights could be placed, and thus the pressure upon the shaft and the center of gravity of the brake could be readily adjusted. Upon the front of the block a plane mirror was fastened, and before it, at a convenient distance, were placed a scale and telescope. When the shaft was turned, the friction between it and the brake caused the latter to turn until the moment of the friction was equal to that of the brake, and the angle at which this equality was established could be read from the scale by the telescope. As the center of gravity was always adjusted so that the brake never revolved through an angle of more than three degrees, the scale readings were approximately proportional to the coefficient of friction; and since relative and not absolute results were sought for, the labor of reduction was not undertaken. Several tables will be given to illustrate the method of conducting a series of experiments with this apparatus.

Table V.

Wrought iron shaft, 1′ diam.; box, cast iron, 1½′ long; load, 100 lbs. Shaft well oiled.

Velocity of the circumference of the shaft.

	No. 1, 72′.	No. 2, 272′.	No. 3, 605′.	No. 4, 1320′.
Scale readings	515	500	...	..
	515	500	...	...
	515	495	...	...
	515	495	...	...
	515	495	...	...
	515	495	...	...
	515	...	485	...
	515	...	485	...
	520	...	485	...
	520	...	485	...
	520	...	485	...
	520	...	490	...
	525	...	...	480
	525	...	...	480
	525	...	...	480
	525	...	...	475
	525	...	...	480
	525	...	...	485
Mean	519	497	486	480
Position of equilibrium	464	464	464	464
Deflections	55	33	22	16

Relative values of the coefficient of friction.

No. 1, 1·00. No. 2, ·60. No. 3, ·40. No. 4, ·29.

The results given above were made with high velocities, and show coefficients of friction decreasing as the velocity increases.

The results of a similar series with very low speeds are given in the next table.

Table VI.

Velocity of the circumference of the shaft: No. 1, ·007′; No. 2, ·027′; No. 3, ·060′; No. 4, ·132′ in a minute.

No. 1, ·37. No. 2, ·51. No. 3, ·73. No. 4, 1·00.

These results, unlike those of the former table, show a coefficient of friction increasing as the velocity increases.

A large number of experiments similar to those given above have been made with uniform results.

I have been able to verify experimentally the law stated early in this paper in the following cases: wood sliding on wood, wood on iron, leather on iron, zinc on iron, and copper on iron; and to obtain results verifying the first half of the law in the case of leather on wood.

The experiments above detailed make it easy to explain the various results obtained by the three authorities quoted at the beginning of this paper. Morin experimented under conditions which gave him a coefficient very near the maximum, and thus his results are approximately constant. Bochet experimented with railway trains, his conditions were high speeds, hard rubbing surfaces, and great intensity of pressure. All these circumstances are favorable to the result he obtained, namely, a coefficient decreasing as the velocity increases. Hirn, on the other hand, employed very light pressures, less than two pounds on a square inch, and kept his rubbing surfaces so thoroughly lubricated that the friction was between oil and oil instead of two metal surfaces: his speeds were not very great. These conditions are precisely the ones I have found favorable to the results he reached,—a coefficient, increasing as the velocity increases. It would be very easy to form a theory which would account for the variation of friction with the velocity, under the rule I have given.

It is well known, that if a given deflection in a bar is produced by a weight acting for five seconds, for example, that the same deflection may be produced, by a less weight, acting for a longer time. Now, as the force required to overcome friction is, partially at least, expended in bending down the minute irregularities on the surface of the rubbing bodies, it becomes evident how, other things being equal, a rapid motion would call for the exertion of a greater force than would be required if the motion were slow.

On the other hand, the longer two surfaces under pressure are in contact the greater must be the interlocking of the irregularities upon the rubbing surfaces. On this account a rapid motion would not require the expenditure of so great a force to overcome the friction. Thus, we have two effects, varying with the velocity, but having opposite signs. Now it is not probable, from the nature of the case, that these effects are numerically equal, or even proportional, and thus we can, at the least, say that the conditions are favorable to the existence of a maximum resultant effect. Having, however, ascertained the fact by experiment, the explanation becomes a matter of minor importance.

It may be said that these facts have no practical importance at the velocities ordinarily employed. I would call attention to Table V, where it will be seen that by increasing the velocity of shafting within the limits of ordinary shop practice, a reduction of the coefficient of friction of quite fifty per cent may be made. The pressure on the shaft might also be reduced, for it would be unnecessary to maintain so great a tension upon the belts, and thus in some cases a very considerable economy of power might be effected. We know that in many shops a large fraction of the power developed by the engine is expended in overcoming the friction of the shafting and machinery.

On the other hand, it is desirable that the friction of the belt upon the pulley should be as great as possible. The conditions usually met with, which determine the friction of belts, are, low intensities of pressure, a rubbing surface which yields with considerable ease. In such cases a high speed is needed to develop the greatest amount of friction. See Tables III and IV.

I am under obligations to Messrs. Butterfield and Wilson, who have rendered me valuable assistance in conducting the experimental work of this investigation.

I hope soon to be able to give tabulated results, which may have a certain practical value to working engineers.

ART. XLI.—*Examination of American Minerals.* No. 6.—*Description of Columbic Acid Minerals from new localities in the United States, embracing a reclamation for the restoration of the name Columbium to the element now called Niobium. Description and analyses of Columbite, Samarskite, Euxenite, and Fergusonite, and the new species Hatchettolite, and Rogersite;* by J. LAWRENCE SMITH, Louisville, Ky.

IT is the common practice of all American chemists and mineralogists to speak of the metal which is called *Niobium* by English and continental chemists, as *Columbium.* This is eminently just, since the metal was discovered and well defined, and named columbium, forty-five years before the name niobium was given to it. The change of name was caused by a double mistake, in no way connected with the original observations in 1801 by Prof. Hatchett of England.

These mistakes arose as follows:—In the first place, Ekeberg discovered in 1802 a supposed new metal which he called tantalum, but which a short time afterward was regarded as identical with columbium; and for forty-five years tantalum and columbium were synonymous terms in all works on chemistry, although Wollaston suspected their dissimilarity; secondly, when H. Rose made his well-known exhaustive researches on the columbite of Bodenmais, he showed that this mineral contained not one but two metallic acids; one of these was *tantalum*, and the other he supposed to be a new metal which he named *niobium.**

Subsequent examination, however, convinced Rose (and his conclusions have been confirmed by others who have repeated his experiments), that the two metallic acids obtained from the Bodenmais columbite were really the original columbic acid of Hatchett, discovered in 1801, and the tantalic acid discovered by Ekeberg in 1802. Instead, however, of calling the first mentioned acid niobic acid, its original name should have been left to it. The result of Rose's researches was in fact simply the demonstration of the actual difference of columbium and tantalum; for Hatchett's discovery was clear, precise, and well made out, and has never been controverted.

This being a correct summary of the history of the composition of the columbium minerals, it is but right, just, and in accordance with chemical and mineralogical precedence, that the name given by the discoverer should replace that of niobium, which originated forty-five years later.

A point of less importance, but worthy of some consideration, is, that this element derived its name from the country in which it was discovered, it being the first and up to the present time, the only element discovered in that part of America usually named Columbia.

In addition to the above, an interesting fact connected with the minerals of this group, is, that all the varieties, save one or two, have been discovered in greater quantities and in larger crystals in the United States than in other known localities; for crystals of columbite weighing from one-half to seven kilograms have been found at or near the locality where the specimen was obtained that was sent to Hatchett, and several other localities far removed from the original one have since been brought to light. More recently, the highly interesting and rare columbate, samarskite, has been discovered in a locality in North Carolina, and already at one spot five hundred kilograms have been taken out. Among the minerals from this last locality, besides the samarskite and columbite, I have detected two new columbates, and also good specimens of euxenite. More recently, I have found columbite embedded in those remarkable crystals of green feldspar—Amazon stone—coming from El Paso County, Colorado, and which are the admiration of all mineralogists.

Besides the above, fergusonite in fine specimens, although small in size, has been found in the granite formation of Rockport, Mass. In fact, if we look at the localities of columbium minerals on the North American continent, they will be found to range from Greenland in the north to Carolina in the south, from Massachusetts on the east to Colorado on the west.

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* H. Rose still supposing that this tantalum was the same as what was known equally well as columbium.

After these remarks in reference to the restoration of the name columbium among the elements, replacing that of niobium, I will detail my researches upon the more recently discovered columbates.

Columbite from North Carolina.

This mineral has been found during the past few years at the mica mines in Mitchel County, and in Yancey County near Burnsville, in the State of North Carolina. It occurs in rocks belonging to the same epoch as those in which the samarskite was discovered, and which will be mentioned more fully when the latter mineral is described.

There is nothing peculiar or striking in the crystalline form of the mineral as found at this locality; many of the crystals that have come under my observation have been compressed and distorted, as is not unfrequently the case with minerals associated with mica. Most commonly I have seen it in irregular lumps weighing from five to one hundred grams. Several pieces have been sent to me under the supposition that they were tantalite, but in no instance have I found it to be the case, the specific gravity never exceeding 5·5 to 5·6.

The specific gravity of the columbite as obtained both for the crystals and for the massive variety is as follows:

Crystals	5·562
Massive	5·485

The analyses of both varieties show that they are chemically identical. The average of several analyses which agreed very closely, is:

	Massive.	Crystals.
Columbic acid*	80·82	80·06
Tungstic and stannic acids	1·02	1·21
Iron protoxide	8·73	14·14
Manganese protoxide	8·60	5·21
Copper oxide	trace	----
	99·17	100·62

The distinctive peculiarity of the composition of this columbite is the large amount of manganese oxide compared with that of the iron in the massive variety, it being greater than that given in the analysis of any other columbite.

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* I refer to the metallic acid in the analyses in this paper as columbic acid from the fact that the tantalic acid which accompanies it is only in small quantities, and also because none of the methods proposed for separating the two acids have given satisfactory results in my hands.

Columbite from Colorado.

Among the magnificent and gigantic crystals of Amazonstone recently discovered in El Paso Co., Colorado—and so energetically explored by A. E. Foote—some specimens were shown me having small black acicular crystals imbedded just beneath their surface. Carefully detaching them from the feldspar, by no means an easy task, and examining the crystalline form, and subsequently the chemical composition, I found them to be columbite. A few small and well-marked crystals have been detached; the largest was a flattened, imperfect crystal, weighing one and one-half grams. Most commonly they are only in the form of black elongated specks. A small amount of the pure mineral that was separated enabled me to make out its composition, although I could not obtain enough for a very careful quantitative examination. The examination made gave a very low specific gravity; it was taken on ·600 gram, and is 5·15. Analysis of ·500 gram gave

Columbic acid	79·61
Iron protoxide	14·14
Manganese protoxide	4·61
Loss by heat	·50
	98·86

Samarskite.

A few small specimens of this rare mineral from North Carolina have been in cabinets for several years, but its exact locality and the nature of its occurrence were first made known in April, 1873, through the agency of Joseph Wilcox of Philadelphia, and subsequently by the investigations and collections made by Rev. J. Grier Ralston of Norristown. Not having visited the locality myself, I have obtained my information concerning it from the above mineralogists. It is found in Wiseman's mica mine, Greesy Creek Township, Mitchel County, near North Toe River, North Carolina. It was obtained while extracting the mica, principally in a kind of pocket in the mine, the miners calling it *black mineral.* Mr. Ralston was very active in having it collected, and in 1875, there had been accumulated about 400 kilograms of the mineral, which was brought away from the mine by him; since that time only a little of it has been taken out of the mines, but in all probability, it will be found again in more or less abundance. Prior to this discovery, the largest pieces of samarskite, found in the Ural locality, were of the size of hazel-nuts; these occur imbedded in a reddish brown feldspar.

Its geological position is in crystalline rocks, in what may be called a coarse granite; the minerals of which rock are not granular, but exist in large masses, so that in extracting the fine blocks of mica, these are readily detached from the other constituents of the granite. The samarskite is generally in close relation to the feldspar, which last, in all the specimens I have seen, was more or less disintegrated; this arises no doubt from the proximity of the samarskite to the surface, it not having been found as yet in the unaltered granite.

For some time after the discovery of this mineral, mineralogists were not agreed as to its being samarskite, no crystals having been found by which to establish its identity, and the partial analyses made not giving concordant results. This discrepancy arose, however, from the intermixture of other minerals, three of which I have detected, two of them being new.

On one occasion I took a specimen of very compact mineral, perfectly clean, and to casual observation perfectly uniform in color and texture; on breaking off a portion from one end of it and taking the specific gravity, I found it to be 5·221, which was so much lower than that of samarskite that I passed it over to my assistant for reëxamination. His results corresponded exactly with mine.

I then broke off a piece immediately contiguous to the one already examined and found its specific gravity 5·682, being that of samarskite. On examining the first piece by breaking off thin scales, I could detect that a portion of them had a very dark brown luster, produced by the mixture of some euxenite, a mineral that I have discovered pure and in all stages of mixture with the samarskite. There is no difficulty, with some little experience, in obtaining any quantity of this mineral with its usual characters.

Aspect of the finest specimens.—Intense jet black, and when broken having a large brilliant conchoidal fracture, perfect, even, and smooth, with the luster vitreous.

It is exceedingly brittle, breaking like black obsidian, with very sharp edges; any one seeing it broken for the first time would take it for black obsidian, until handled, when its weight would indicate that it was another mineral. All the pieces of pure samarskite are not equally brilliant in fracture as above described, but approach to it more or less.

Hardness.—I should say that it was 5·5 to 6, nearer 6, but owing to the brittleness of the mineral it is not easy to fix its exact hardness.

Specific gravity.—5·72.

Crystalline form. —I am indebted to Mr. Ralston for the inspection of the only specimens from which its crystalline form could be made out, and these have been thoroughly described and studied by Mr. Edward S. Dana; the examination made by this skillful crystallographer is to be found in this

Journal, March, 1876, page 201; he also first published an account of the region in which it is found, and gave an account of the associated minerals.

Composition.—This mineral from North Carolina has already been examined three times. In 1852, Prof. T. Sterry Hunt examined a small piece of the mineral, less than one gram, said to have come from Rutherford County; again, Miss Ellen H. Swallow has given a most excellent analysis of the samarskite from Mitchel Co. agreeing with those made by myself as nearly as the analyses of such a mineral can be expected to do when made on different specimens; and finally, Prof. Allen has made an analysis, which is to be found on p. 340 of Dana's Text Book of Mineralogy (March, 1877). The following are the analyses, (1) of myself, (2) of Miss Swallow, and (3) of Prof. Allen.

	(1)	(2)	(3)
Columbic acid	55·13	54·96	37·20
Tantalic acid			18·60
Tungstic and stannic acids	0·31	0·16	0·08
Yttria	14·49	12·84	14·45
Cerium oxides*	4·24	5·17	4·25
Uranium oxide	10·96	9·91	12·46
Manganese protoxide	1·53	10·91	0·75
Iron protoxide	11·74	14·02	10·90
Magnesia	trace	....	0·55CaO
Loss by ignition	·72	0·52	1·12
Insoluble residue from cerium oxide	....	1·25	....
	99·12		100·36

The late Heinrich Rose, in describing the samarskite of Miask, gives an analysis by Finkener and Stephans,† which differs from the analysis previously made, as well as from those now detailed, indicating the presence of four per cent zirconia, and six per cent of thoria. The announcement of the presence of the latter named oxide has been one of the causes of the delay of my publishing this paper, for I desired if possible to verify the results of Finkener and Stephans It is only recently that I have obtained a few grams of pure Miask samarskite, from the School of Mines of St. Petersburg, through Prof. Norpé, but all of this, except about 1½ grams, was lost after reaching me, so I have not been able to do more than make an imperfect examination; and this examination shows that there is some difference in the earthy oxides from those in the North Carolina specimens, the exact determination of which I must postpone for some future occasion.

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* I record these oxides as cerium oxides, but I am not altogether satisfied in regard to their true nature and proportion of the respective oxides, which are now undergoing a chemical examination.

† Verhandlung. Min. St. Pet., 1863, 13.

Euxenite.

In examining portions of the samarskite, that was surrounded by decomposed feldspar, I detected a mineral not having the intense black of the samarskite, but of a brownish color with a streak and powder much lighter than that of samarskite; and in pushing my researches further, the mineral was obtained still lighter, of a hair brown color, the powder being of an ash color. In thin fragments it is translucent; the fracture is subconchoidal, but in most instances irregular, with a resinoid luster.

Its aspect made it very evident that it was something different from the samarskite, and an examination proved this opinion correct, and established its true mineralogical position.

No crystals have been found, so it is not possible to establish its identity in crystallization with euxenite; but all its other physical and chemical properties are those of that mineral.

The specific gravity of pieces taken from different specimens was respectively 4·593, 4·620, 4·642. On analysis it was found to contain

Columbic acid	54·12	Uranium oxide	9·53
Tungstic and stannic acid	·21	Manganese protoxide	·08
Yttrium and cerium oxides	24·10	Iron protoxide	·31
Lime	5·53	Water	5·70
			99·58

The columbic acid was tested most carefully for titanic acid, both by fusion with bisulphate and with carbonate of potash, but none of it could be detected; only 5 milligrams of a residue was obtained as a result in these analyses, and it is well known to analysts that this is most probably attributable to columbic acid.

I need hardly insist that the above properties belong to the mineral euxenite: they approaching closely that from Tromoen, analyzed by Strecker, except, that this chemist makes as much as sixteen per cent of the metallic acids to be titanic acid. This euxenite represents a purer type of a columbate than most of those of which analyses are given, while it is also remarkable for the small quantity of iron oxide in it; being a hydrated columbate of yttria, uranium and lime.

Hatchettolite—a new Columbate.

This is an additional one of the series of columbic acid minerals found with the samarskite of North Carolina. My attention was first called by Mr. Ralston to some octahedral crystals that he had diligently uncovered from the disintegrated feldspar, which had to all appearance some connection with the samarskite. He had sent two or three of these crystals to Edward S. Dana some time before, and this last mineralogist was inclined first to refer it provisionally to pyrochlore, but finally on account of its high specific gravity suggested its possible relation to microlite. (See this Journal, March, 1876, page 204). No further steps having been taken to settle the character of this mineral, I undertook its examination on specimens furnished me by Mr. Ralston, and also on a specimen I afterward found in carefully examining the altered gangue of the samarskite in my possession.

The result has been the establishing of a new mineral of this series, which I have called Hatchettolite, from the discoverer of the element columbium. It occurs in regular octahedrons, but of the six crystals that I have examined, all have the cubic planes and the form 3-3, and E. S. Dana observed the same on the crystals he examined.

In referring to these modifications, I would state that, among eight or ten crystals of pyrochlore seen by me I have never observed them, although this last mineral is found with them, as may be seen in M. Kokscharow's magnificent work on Russian minerals. I could not detect any distinct cleavage. Its hardness is about 5: perhaps a little over. Specific gravity: that of a fine small crystal was found to be 4·851; of small fragments well selected from a large crystal that had mica in some part of it, 4·785. Prof. Brush obtained (as quoted by E. S. Dana) 4·794.

It is well to add here the specific gravity of a very fine crystal of pyrochlore, weighing one and one-half grams; as taken by myself, it is 4·25. That of microlite—another octahedral columbate,—by Shepard and Hayes, is 5·484.

Color of Hatchettolite.—Yellowish brown with a grayish opalescence; on heating to redness becomes of an opake greenish yellow; luster resinous; fracture subconchoidal.

Composition.—I made three analyses, the first two on fragments from the specimens of Mr. Ralston, and the third from a specimen in my own collection. The mineral was broken into pieces from 2 to ½ mm. in diameter, and then carefully selected under the glass to avoid admixture of any other mineral. Thus selected it was found to contain:

Columbic acid	66·01	67·86	67·25
Tungstic and stannic acids	·75	·60	·91
Uranium oxide	15·20	15·63	16·01
Lime	7·72	7·09	7·11
Yttria and cerium oxide	2·00	·86	·64
Iron protoxide	2·08	2·51	2·12
Potash	·50	1·21	not estimated
Water—lost by heat	5·16	4·42	5·02
Lead	trace		
	99·42	100·18	99·06

It will be seen that the special difference between this mineral and pyrochlore is that its predominating base is uranium oxide, which last mineral, according to Wöhler's analysis of that from Miask, does not contain any of this oxide, though the analyses of others give a small quantity of it. It is to be supposed that Wöhler examined the best and purest type of the mineral in that from Miask.

Rogersite, a new columbate.

On some of the samarskite, but more especially on the euxenite, a white crust was found adhering with some degree of firmness, and on examining it under the glass, it presented a mammillary structure, sometimes like little pearly beads. When on the euxenite it is more readily separated than when on samarskite. By pressing on it with a sharp point, it becomes detached in small fragments.

I have called this mineral Rogersite, in honor of the American geological Nestor, Wm. B. Rogers, whom we all delight to honor for his important labors in scientific and economic geology, from an early date up to the present day.

The quantity that has as yet been discovered is very small. Mr. Ralston possesses the finest specimen, which is about the size of the hand, with four or five grams of this mineral on the surface, quite pure and very characteristic. I had to operate on a great number of small pieces carefully detached, which have enabled me to establish its true character.

It is readily recognized by its well marked mammillary structure even when the fragment is quite small. Its hardness is about 3·5; specific gravity 3·313.

I made two analyses, each time on small portions. The results furnished were:

Water	17·41	16·34
Columbic acid	18·10	20·21
Yttria, etc.	60·12	

In the second analysis, owing to an accident, the yttria was lost; the first also shows about 4 per cent not accounted for.

These analyses are to be taken only as approximative, for before complete and reliable analyses of this mineral can be made, a larger quantity will be required The mineral is an interesting one, as being the first columbate discovered so largely hydrated. It has evidently resulted from the decomposition of either samarskite, or euxenite, or both.

Fergusonite.

Two years ago a dark brown mineral, with a remarkably bright and perfect conchoidal fracture, was shown to me by Mr. W. E. Knowlton of Boston, who obtained it from the granite quarries of Rockport, but its nature had not been determined. The quantity then found was very small and only a portion of it was given to me; a short time afterward, I informed Mr. Knowlton that it was fergusonite, and requested him to look further for specimens. Since then but little more has been found, but enough was furnished me to make out its true character, both physically and chemically, except its crystalline form. It is found particularly at one locality near the intersection of two trap dykes.

For a space covering about thirty or forty feet, masses of feldspar and quartz replace the granite, and it is in the feldspar that the Fergusonite is found, intimately associated with cyrtolite, and sometimes even penetrating crystals of this last mineral. In the same feldspar, annite, cryophyllite, and fine crystals of smoky quartz are found.

The mineral is of a fine dark brown color in the interior, with a clear conchoidal fracture; resinous luster;* hardness 6; specific gravity 5·681; streak light brown; powder, ash-colored; but when heated to a bright red heat for fifteen minutes changing to a light greenish yellow color with a loss of 1·50 per cent.

Columbic acid	48·75
Yttria	46·01
Cerium oxides	4·23
Iron and uranium oxides	·25
Water (loss by heat)	1·65
	100·89

It corresponds very nearly in composition with the fergusonite from Greenland.

Remarks as to the chemical character of the minerals described.

The compositions of the columbates from the various localities appear at first sight to be very complex and irregular, but if examined critically, and due allowance be made for the intermixture of these minerals, which intermixture cannot be detected on account of the similarity of color and fracture of the different minerals, this irregularity disappears to a greater or less extent.

The first, and the one best known, *columbite*, is well recognized as a simple columbate of iron and manganese.

Microlite, from what little we know of its composition, appears to be a columbate of lime. *Pyrochlore* is to be regarded as a columbate of the cerium oxides and lime; whether or not a neutral columbate, further examination is to determine.

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* The action of a red heat on small fragments is to change their color to a greenish yellow; but before this takes place, the fragments exhibit the phenomenon of glowing in a manner more striking than any specimens of gadolinite, a mineral remarkable for its glowing, that I have experimented with. From lack of material I did not take the specific gravity after heating.

Hatchettolite is doubtless a neutral columbate of uranium oxide and lime. Then, when we pass to the *samarskite*, we have a basic columbate of iron, uranium and yttrium oxides. *Yttrotantalite* and *euxenite* are basic columbates, the former anhydrous when pure, the latter hydrated, both being basic columbates of yttria and uranium oxides.

Fergusonite is a hydrous basic columbate of yttria; and *Rogersite* is a hydrated columbate of yttria, still more basic.

In making this general review of these minerals, of course I have not regarded those variable constituents existing in small quantities and replacing more or less one or other of the preponderating bases of each species.

The analysis and chemical study of the above Minerals.

I have several points under this head to consider and to describe in detail; but it more properly belongs to another paper, which will supplement this, for I am now studying the earthy oxides associated with the yttria of the North Carolina minerals, which I am far from being satisfied contains cerium oxide, although some of the reactions of cerium oxide are obtained, a fact already mentioned in a note to the description of samarskite. I am separating the earths from one kilogram of the mineral, which when obtained will furnish material enough for the proper solution of this question.

ART. XLII.—*On the Sensitiveness to Light of various Salts of Silver;* by M. CAREY LEA.

SALTS of silver may exhibit sensitiveness to light in three several ways. They may exhibit a visible darkening, or they may receive a latent image, and this latent image may have a capacity of being rendered visible either by receiving a deposit of metallic silver or by decomposition by alkalies in connection with reducing agents. These two last mentioned phenomena are very distinct in their character, for in the first of them the image is produced entirely by the addition of silver not previously present. In the second, no silver whatever is added, but that portion of substance which received the direct action of light, undergoes decomposition by subsequent treatment. In both cases the action of light sets up a molecular change. The portions acted upon by light become, in the one case, more apt to attract a precipitate in the act of formation (for example, silver precipitated by ferrous sulphate); in the other case they are more readily attacked by certain reducing agents.

The silver compounds which exhibit the greatest tendency to form latent images by the action of light are of course the iodide, bromide, and chloride. But the same tendency is shared to a less degree by other compounds, and the latent image formed upon them may belong to either of the above mentioned classes. The capacity of a certain number of silver salts to receive latent images, developable by a precipitate in the act of formation, was examined many years ago by Mr. Robert Hunt. Since then the matter has received but little attention, and if I am not mistaken, no investigations have at any time been made as to the capacity of silver salts other than iodide, bromide, and chloride to receive latent images of the second sort, viz: those susceptible of alkaline development, in the entire absence of silver nitrate. This subject I have recently examined with the following results:

Soluble salts of acids capable of forming insoluble or nearly insoluble salts with silver were selected and the surface of very pure paper was impregnated with them. After drying, the papers were floated on a solution of silver nitrate, containing about twenty grams to the ounce, acidulated with half a drop of nitric acid, sp. gr. 1·28 to the ounce of solution. The excess of silver nitrate was then washed out. One set of papers were then simply dried, another set were soaked for about a minute in a ten grain solution of gallo-tannic acid, and then again washed.

The salts thus formed on the surface of the paper were exposed to a strong diffuse light for, in some cases, twelve seconds, in others, seven. They were then submitted to the action of a very weak solution of pyrogallol, ammonium carbonate and potassium bromide, the latter used to check the rapidity of the action of the other agents.

Silver citrate and *tartrate* both gave rather weak images. The citrate showed a strong tendency to irregular reduction. Nothing of this appeared in the case of the tartrate.

Silver platinocyanide gave quite a strong image, stronger than any other substance tried, except of course the silver bromide used for comparison.

Silver mucate gave a very faint image with much irregular reduction.

Silver pyrophosphate behaved in the same way.

Silver arsenite gave a moderately strong image, coming next to the platinocyanide, and like it, clear and free from all irregular reduction.

Silver sulphocyanide, an extremely faint image with much irregular reduction.

Silver antimonio-tartrate, a weak image entirely free from irregular action.

Silver fulminurate, weaker than the last mentioned, but also clear.

Silver nitrite, similar to the last.

Silver hippurate, an excessively faint image with much irregular reduction.

The following substances showed (with the above mentioned exposures) no trace of a latent image:

Silver salicylate,
" *valerate*,
" *succinate*,
" *sulphite*,
" *resinate*,
" *phosphate*,
" *metaphosphate*,
Silver tungstate,
" *ferrocyanide*,
" *nitroprusside*,
" *chromate*,
" *carbonate*,
" *oxalate*.

As these experiments were strictly limited to the subject under investigation, viz: production of latent images capable of development by the action of pryrogallol and ammonia it must be understood that the insensitiveness spoken of is *insensitiveness to this particular action* with a rather brief exposure, and under the conditions mentioned. And this action is that to which the iodide, bromide, and chloride, exhibit their highest degree of sensitiveness, rendered evident by an exposure very much shorter than that given in these investigations.

As respects the action of tannin, which action was separately investigated with respect to every one of the above salts, it appeared that no substance, insensitive in the absence of tannin, acquired sensitiveness by its presence. It was also doubtful if in any case tannin increased the sensitiveness of any of these substances, a fact which, in view of the increased sensitiveness conferred by tannin on the silver haloids, is remarkable.

Philadelphia, March 22, 1877.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Chemical Actions of the Silent Electric Discharge.*—BERTHELOT has published in full his memoir on the various chemical actions which he has observed to be produced by the silent electric discharge (*effluve electrique*). The first part treats of the absorption of nitrogen by organic substances under these conditions, and has already been noticed in these pages. The second part treats of the same absorption under the influence of atmospheric electricity, the experiments being made at the Meteorological Observatory of Montsouris, one armature of the apparatus being put in contact with the earth and the other with a layer of air two meters above it, the difference of potential being measured by means of a Thomson-Branly electrometer. Twelve tubes were employed, in five of which moistened filter paper was placed, in the

second five moistened dextrin, while the last two contained internal armatures of silver and were filled with oxygen in order to detect the formation of ozone. Two of each of the five tubes were filled with pure nitrogen, two of each with ordinary air, while the remaining one of each sort was left open to the air. The experiments continued from July 29 to October 5, 1876, the mean electric tension being that of 3·5 Daniell cells, though it varied from + 60 to − 180 during the two months. In the ten tubes containing nitrogen or air, the nitrogen was fixed by the organic substance forming an amide which soda-lime decomposed at 300° to 400°, yielding ammonia. The third part considers the importance, in view of the facts above described, of studying in a connected and methodical manner the electric state of the atmosphere, since the fixation of nitrogen in this way must play an important part in the fertilization of the soil, in the theory of fallowing, and in the development of plants and agricultural products. In the fourth part, Berthelot considers the absorption of free hydrogen by organic matters under the same circumstances. Benzene absorbed 250 times its volume of hydrogen, yielding a polymer of C_6H_8. Turpentine oil and acetylene acted similarly; the latter yielding a solid polymer which on heating yielded ethylene, crotonylene, and ethyl hydride. The fifth part treats of the formation and decomposition of binary compounds by the silent discharge. A mixture of one volume nitrogen and three volumes hydrogen yields three per cent of ammonia, while ammonia is decomposed yielding three per cent of its constituent gases. Sulphurous oxide yields ten per cent of free oxygen and insoluble sulphur. Carbonous oxide yields Brodie's hypocarbonous oxide C_4O_3. In the sixth part the various forms of apparatus used by the author in these researches, are described.—*Ann. Chim. Phys.*, V, x, 51, Jan. 1877. G. F. B.

2. *Is Nitrogen oxidized by Ozone in presence of Alkalies?*—The statement made by Schönbein in 1849, that ozone united with free nitrogen in presence of alkalies to form nitrous compounds, is generally accepted, as furnishing an important basis for the received theories of nitrification. BERTHELOT has examined the question anew, taking care to avoid the causes of error existing in Schönbein's experiments, two in number; first the use of lime water, which generally contains nitrates; and second the use of unwashed ozone from the phosphorus, which contains nitrous compounds produced in the slow oxidation of the metalloid. Oxygen collected over boiled water was ozonized by the silent discharge, and four liter flasks were three-fourths filled with it, the other fourth being filled with air. Ten c. c. baryta water were placed in each and allowed to remain over night. Although the ozonized oxygen contained twenty-three milligrams of ozone in a liter, not a hundredth of a milligram of nitrate was formed in the four flasks. Air ozonized by phosphorus and allowed to stand twenty-four hours, and which contained 5·7 milligrams ozone per liter, gave less than a twentieth of a milligram of nitrate; essentially the same result. The author concludes therefore that ozone does not

oxidize nitrogen under these circumstances.—*Bull. Soc. Ch.*, II. xxvii, 160, Feb. 1877. G. F. B.

3. *On the Equivalence of Nitrogen.*—VICTOR MEYER has replied to the paper of Ladenburg and Struve, noticed in the April number of this Journal, and states that he has carefully repeated their experiments, but with an entirely different result. So far as the question of the decomposition of triethylbenzylammonium iodide and the non-decomposition of benzyltriethylammonium iodide on evaporating their solutions, is concerned, Meyer finds that neither body yields a trace of benzyl iodide on evaporation; and hence that the "prägnante Unterschied" between these bodies, upon which the assertion of the non-equivalence of the bonds of nitrogen rests, has no existence. The author supposes that the salt used by Ladenburg and Struve contained some dibenzyldiethylammonium iodide, a body which gives benzyl iodide on distillation.—*Ber. Berl. Chem. Ges.*, x, 309, March, 1877. G. F. B.

4. *A new metallic element, Neptunium.*—HERMANN has made an exhaustive research on the metals of the tantalum group, in which he not only claims to have established the existence of his element ilmenium, but also the discovery of another metal, belonging to this group, which he calls *Neptunium.* The mineral worked on was labelled tantalite from Haddam, Connecticut; but proved on examination to be columbite and ferroilmenite in equal parts. The metallic oxides separated from the mineral consisted of Ta_2O_5 32·39, Cb_4O_7 36·79, Il_4O_7 24·52, Np_4O_7 6·30. To obtain the neptunium, the pulverized mineral was fused with hydro-potassium sulphate, the acid hydrates digested with ammonium sulphide and hydrochloric acid, washed well with water, dissolved in hydrofluoric acid, mixed with an equivalent quantity of potassium fluoride, and the solution diluted to forty parts boiling water to one of fluoride. On cooling, tantalum-potassium fluoride crystallized in delicate prisms. On evaporation, columbium-potassium fluoride and ilmenium-potassium fluoride crystallized out, leaving an acid mother-liquid. This was diluted with twenty parts water, heated to boiling and sodium hydrate added in excess. An amorphous precipitate of sodium neptunate was formed, mixed with minute crystals of columbate. The precipitate was collected on a filter, pressed out, and boiled with twenty-five parts of water. The columbate dissolved, the neptunate remained. The latter was fused with hydro-potassium sulphate, the fusion was treated with boiling water and the undissolved residue of neptunic acid washed and dried over sulphuric acid. Neptunic acid resembles in general the other acids of the group, but is distinguished from columbic and ilmenic acids by the insolubility of the sodium double fluoride and from tantalic acid by the ready solubility of its potassium double fluoride. Neptunic acid gives with phosphorus salt in the inner blow-pipe flame a wine-yellow bead, the sodium salt a gold-yellow glass, while tantalic acid gives no color, columbic acid gives blue and ilmenic acid gives brown. With tincture of galls, the sodium salts give, on addition of hydrochloric acid a sulphur-yellow precipitate with tantalic, orange with columbic,

brick-red with ilmenic, and cinnamon-brown with neptunic acid. Boiled with tin and hydrochloric acid neptunic acid gives, like columbic and ilmenic acids, a blue solution. From the pure crystallized double potassium fluoride, the atomic weight of neptunium was fixed as 118, its atomic volume as 18, and its specific gravity as 6·55. The formula of the acid is $Np_4O_7,(H_2O)_5$. The sodium salt crystallizes in prisms. The author prepared metallic columbium and ilmenium in the pure form and determined the amount of oxygen taken up by these metals on heating them in the air. Columbium required 20·49 and ilmenium 37·96 of oxygen; the amount obtained by Rose being 20·60 and by Marignac 38·00. Rose, therefore, it is clear, had pure columbium; while it is equally clear, according to Hermann, that Marignac must have had nearly pure ilmenium. This is stated to be a necessary result from the method of preparation. After crystallizing out the tantalum-potassium fluoride, Marignac evaporated and re-crystallized, obtaining a nearly pure ilmenium-potassium fluoride, from which he prepared his metal. Hermann's paper concludes with an account of his methods of separating the metals of this group, and descriptions of their compounds.—*J. pr. Ch.*, II, xv, 105, Feb. 1877.

G. F. B.

5. *On the Phosphorescence of Organic Liquids.*—RADZISZEWSKI, having had his attention called to the phosphorescence of lophin when acted on by potassium hydrate and oxygen, has extended his observations to other bodies and finds that paraaldehyde, metaaldehyde, aldehyde-ammonia, furfurin, hydroanisamide, anisidine, hydrocumamide, and hydrocuminamide, have all the same property. Since these bodies are all either aldehydes or ammonia derivatives of aldehyde, their luminosity may be due to the oxidation of the aldehyde. He therefore examined formic aldehyde, and observed a bright phosphorescent light when its solution in alcohol potash was agitated, and the formation of potassium formate was proved. In the light of Duchemin's statement that *Noctiluca miliaris* produces on delicate skins an irritation like nettles, the author suggests that this animal, like ants, secretes formic acid not as such but as the aldehyde, which in the process of oxidation is the cause of their luminosity. When a current of oxygen is passed through a hot alcoholic solution of grape sugar containing potash, it becomes weakly luminous, a fact which in so far, confirms the aldehyde nature of glucose.—*Ber. Berl. Chem. Ges.*, x, 321, March, 1877. G. F. B.

6. *On Melezitose.*—In 1858, Berthelot described a new compound sugar existing in the Briançon manna prepared from the larch (*Larix Europea*). VILLIERS has now examined a manna collected in Lahore, produced by exudation from the *Alhagi Maurorum*, a thorny shrub belonging to the family of the Leguminosæ. It is abundant in Persia, where it is used both for medicine and as food under the name of Turanjbin. Crystallized from water and then from alcohol, it was obtained in the form of white bulky crystals, containing one molecule of crystal-water which they lose even in dry air at the ordinary temperature, and then

have the formula $C_{12}H_{22}O_{11}$. Its solution is dextrogyrate, rotating +94° 48′ referred to the neutral tint, or 88° 51′ referred to the yellow light of sodium. On ebullition with dilute sulphuric acid, the rotary power changes slowly, being reduced at the end of an hour to +53°. It does not reduce copper tests until after reduction, and yields on oxidation with nitric acid, oxalic acid only. It melts at 140°. All these points prove it to be identical with the melezitose of Berthelot. It crystallizes in clinorhombic prisms.—*Bull. Soc. Ch.*, II, xxvii, 98, Feb. 1877. G. F. B.

7. *Tri-substitution derivatives of Benzol;* by EDGAR F. SMITH, Ph.D., Assistant in Analytical Chemistry, University of Pennsylvania. (Abstract of Inaugural Dissertation at Göttingen, 1876.)—The investigation of the tri-substitution compounds of benzol has only of late engaged the attention of chemists. The following results, recently obtained by me, are presented as a contribution to the knowledge of bibromnitro-, bibromamido-, tribrom-, and bibromhydroxylbenzoic acids.

PARABROMMETABROMNITROBENZOIC ACID.

$C_6H_2Br^pBr^mNO_2COOH$. Fusing point 162° C.

This acid was obtained by nitriring parabrommetabrombenzoic acid discovered by Hübner and Burghard (Burghard's Dissertation, Göttingen, 1875). The fusing point of this latter acid is 22[illegible]°–230° C. To effect the introduction of the nitro-group (NO_2), the acid obtained by the above chemists was heated upon a water-bath with fuming nitric acid. The application of a more intense heat produces entirely different acids. In the cold, fuming nitric acid was without action upon the bi-brom acid.

After the conversion of the bibrom acid into the corresponding nitro-acid by means of fuming nitric acid, aided by gentle heat, the whole is allowed to cool and water then added to the solution. The bi-bromnitro acid was partially precipitated in flocculent masses; the greater quantity of the acid, however, remained dissolved. All of it was obtained by evaporating the solution, placed in a porcelain dish, to dryness upon a water bath, and the residue purified by boiling it with sodium carbonate.

In hot water the acid is easily soluble, crystallizing from it in fine colorless needles. The fusing point was found to be 162° C. The acid is not volatilized by steam. When heated between watch glasses it sublimes with partial decomposition. It is very probable this acid is identical with that obtained by Hübner and Angertein (Angertien's dissertation, Göttingen, 1869). The relation of the nitro-radical to the COOH-group or to the bromine atoms has not yet been determined.

Parabrommetabromnitrobenzoate of Lead: $(C_6H_2Br^pBr^mNO_2COO_2)_2Pb$. Obtained by precipitating a hot solution of the potassium salt with lead acetate. A white insoluble powder.

Lead estimation, 0·2755 grm. dry salt gave 0·0965 grm. $PbSO_4$ =0·0659 grm. Pb = 23·95 per cent. Theoretical percentage = 24·21 per cent Pb.

Carbon and hydrogen determination: 0·2143 grm. salt gave 0·0433 grm. carbon = 20·1 per cent. Farther, 0·0256 grm. H_2O = 1 per cent H.

Nitrogen determination: 0·1581 grm. salt = 3·53 per cent N.

Theoretical percentages = Carbon, 19·7 per cent, hydrogen 0·50 per cent, nitrogen = 3·26 per cent.

Parabrommetabromnitrobenzoate of Sodium: $C_6H_2Br^pBr^mNO_2COONa+3H_2O$. This salt crystallizes from dilute solutions in needles, often forming bundles. From concentrated solutions it is obtained in almost colorless, broad shining leaflets. Soluble in cold and hot water. The anhydrous salt requires 6·63 per cent Na. Found 6·66 per cent Na.

Parabrommetabromnitrobenzoate of Potassium: $C_6H_2Br^pBr^mNO_2COOK$. The pure acid was boiled with potassium carbonate, the salt crystallizing from the solution in needles. Very soluble in warm water.

Anhydrous salt requires 10·76 per cent K; found 10·61 per cent K.

Parabrommetabromnitrobenzoate of Barium: $(C_6H_2Br^pBr^mN_2OCOO)_2Ba+H_2O$. Broad colorless, shining needles, easily soluble in water. Anhydrous salt requires 17·45 per cent Ba; found 17·34 per cent.

Parabrommetabromnitrobenzoate of Calcium: $(C_6H_2Br^pBr^mNO_2COO)_2Ca+3\frac{1}{2}H_2O$. Obtained by boiling the free acid with either calcium hydrate or carbonate. Exceedingly difficult to obtain pure. Occurs in red-colored needles, almost insoluble in water. The analysis of the anhydrous salt gave 5·52 per cent Ca; required 5·81 per cent Ca.

Parabrommetabromnitrobenzoate of Magnesium: $(C_6H_2Br^pBr^mNO_2COO)_2Mg$. Crystallizes in needles forming star-shaped groups. Difficultly soluble in water. Analysis gave 3·25 per cent Mg; required 3·59 per cent.

PARABROMMETABROMAMIDOBENZOIC ACID.

$C_6H_2Br^pBr^mNH_2COOH$. Fusing point 225° C.

Very easily obtained from the preceding acid by heating it with hydrochloric acid and a calculated amount of tin. The amiding takes place without any violent action. The acid only unites with bases, not with acids. Soluble in a large quantity of water; readily soluble in a mixture of equal parts alcohol and water, from which it crystallizes upon cooling in beautiful flocks consisting of minute needles. The fusing point of the acid is 225° C., considerably higher than that of a similar acid obtained by Angertein (Dissertation, Göttingen, 1869). Completely decomposed when fused. A nitrogen determination was made of the free acid. Required percentage of Nitrogen = 4·75 per cent; found 5·03 per cent N.

Parabrommetabromamidobenzoate of Barium: $(C_6H_2Br^pBr^mNH_2COO)_2Ba+4H_2O$. An aqueous solution of the sodium salt was decomposed with barium chloride, the precipitate filtered and washed. The salt forms minute shining needles, generally united to bundles. Very soluble in water. Analysis of anhydrous salt gave 18·90 per cent Ba; required 18·89 per cent.

Parabrommetabromamidobenzoate of Calcium: $(C_6H_2Br^pBr^m NH_2COO)_2Ca+4\frac{1}{2}H_2O$. Obtained by decomposing the ammonium salt with calcium chloride. The salt is tolerably insoluble in water, crystallizing from it in small reddish-brown colored needles. Analysis gave 6·37 per cent Ca; required 6·51 per cent Ca.

Parabrommetabromamidobenzoate of Strontium: $(C_6H_2Br^pBr^m NH_2COO)_2Sr+2H_2O$. Large, dark-red colored needles. Difficultly soluble in hot water. An analysis of the anhydrous salt gave 12·55 per cent Sr; required 12·93 per cent Sr.

Parabrommetabromamidobenzoate of Copper: $(C_6H_2Br^pBr^m NH_2COO)_2Cu$. From the ammonium salt by treating it with copper acetate. Bright green in color; perfectly insoluble in water. Analysis: 9·23 per cent Cu found; required 6·70 per cent Cu.

TRIBROMBENZOIC ACID.

$C_6H_2Br^pBr^mBr^?COOH$. Fusing point 195° C.

I obtained this acid by converting the preceding bibromamidobenzoic acid, by means of nitrous acid, into the corresponding diazo-compound and then boiling this last product with pure concentrated hydrobromic acid. The pure acid obtained from the barium salt after many recrystallizations, presented the constant fusing point 195° C. The acid is almost perfectly insoluble in water. Very soluble in a mixture of one part water and two parts of alcohol, recrystallizing out of this in small colorless needles. Fuses with partial decomposition.

Tribrombenzoate of Lead: $(C_6H_2Br^pBr^mBr^?COO)_2Pb$. Obtained by precipitating the ammonia salt with lead acetate. It forms a white insoluble compound. This salt was taken in estimating the carbon and hydrogen. Found 17·98 per cent carbon, and 0·89 per cent hydrogen. Calculated 18·20 per cent carbon, and 0·43 per cent hydrogen.

The bromine was determined by burning the pure acid with oxide of lime and the calcium bromide decomposed by silver nitrate. Found percentage of bromine, 66·85 per cent; calculated 66·48 per cent.

Tribrombenzoate of Barium: $(C_6H_2Br^pBr^mBr^?COO)_2Ba+5H_2O$. Formed when the free acid is boiled with barium carbonate. The pure salt forms needles easily soluble in water. The anhydrous salt when analyzed gave 15·53 per cent Ba; calculated 16·06 per cent Ba.

PARABROMMETABROMOXYBENZOIC ACID.

$C_6H_2Br^pBr^mOH^?COOH$. Fusing point 218° C.

An etherial solution of parabrommetabromamidobenzoic acid was treated with nitrogen trioxide until the corresponding diazo-compound formed, and being insoluble in ether fell out in flocculent masses. The diazo-compound, perfectly dry, was boiled with pure water—the OH group being thereby introduced. This acid is difficultly soluble in water. The fusing point is 218°. It crystallizes in colorless needles. When fused, partial decomposition occurs. A beautiful violet color is imparted to its solution, when treated with a few drops of ferric chloride. A combustion of the acid gave 29·00 per cent carbon and 1·28 per cent hydrogen; calculated 28·38 per cent carbon and 1·35 per cent hydrogen.

Parabrommetabromoxybenzoate of Sodium: $(C_6H_2Br^pBr^mOH' COONa)+H_2O$. Obtained by boiling the barium salt with sodium carbonate. The salt is exceedingly soluble in water, forming light yellow colored needles, frequently united to bundles. An analysis of the anhydrous salt afforded 7·45 per cent Na; required 7·23 per cent Na.

Parabrommetabromoxybenzoate of Barium: $(C_6H_2Br^pBr^mOH' COO)_2Ba$. When an aqueous solution of the acid is boiled with barium carbonate, this salt is formed. It crystallizes in red warty masses. It is rather insoluble in water. I obtained by analysis 18·80 per cent Ba; required 18·84 per cent Ba. E. F. S.

Philadelphia, Pa.

8. *Kinetic Theory of Gases.*—M. BOLTZMANN, in a communication to the Vienna Academy on the nature of gas molecules, abandons the notion that they behave like aggregates of material points (the atoms). He considers that in estimating the impact action of the molecules we may almost regard the whole aggregate which we denote as an individual gas molecule, and which may consist of different substances, perhaps even ether atoms, as rigid. It is found that then the ratio of the heat-capacities of the gas must be 1⅔, when the gas-molecules have a ball-form. The ratio of the heat-capacities will be 1·4 if the molecules have the form of rigid bodies of rotation, but which are not balls; and 1⅓ if they are of any other form of rigid bodies. These numbers at least seem to agree so far with those found experimentally, that one cannot say that experiment furnishes a contradiction of the theory thus modified. It is further shown that the values experimentally got for the heat-capacity, under this view, are in satisfactory agreement with the heat-capacities of solid bodies. Of course the gas molecules cannot be absolutely rigid bodies; this is already disproved by spectral analysis, but it may be that the vibrations producing gas spectra are merely brief shiverings during the shock of two molecules, comparable to the sound perceived on the shock of two ivory balls.—*Nature*, xv, 306.

E. C. P.

9. *Vowel "Clang."*—M. AUERBACH, from researches on the nature of the vowel "clang," in Prof. Helmholtz's physical laboratory, comes to the following conclusions, which appear to throw new light on some unsolved problems:—1. All clang, especially the vowels of the human voice and speech, are to be defined as the consequence of the joint action of two moments, a relative and an absolute. 2. The relative moment is the mode of distribution of the whole intensity among the individual partial tones as deter-

mined by their ordinal number. The absolute is the dependence of the whole intensity of the absolute pitch of the partial tones, and the modification of the distribution, are clangs of the fundamental tone therewith connected. 3. The difference of the vowels in the former relation is a result of the power of changing the form of the mouth cavity. The differences of the absolute pitches characterizing the various vowels, and of their influence, are a result of the power of changing the volume and size of the mouth cavity. 4. The first partial tone is always the strongest in clang; it deserves, therefore, the name of fundamental tone. 5. The intensity of the partial tones as such, decreases in general as their ordinal number increases; exceptions indicate the nearness of the boundary of the consonant region. 6. The intensity of the partial tones decreases more slowly the nearer the vowel clang is, therefore more quickly the duller this is. 7. The characteristic pitch is higher the clearer, and deeper the duller, the vowel clang. 8. The variations of the intensity, in consequence of the influence of the characteristic pitch, are greater the fuller the vowel is. Very slight variations indicate the nearness of the consonant region. 9. All the vowels admit of being sung within the whole range of the human voice; but the dull speak in very high, the clear in very deep, positions. 10. A little attention only is needed to perceive in a vowel clang the over-tones (often comparatively very strong), without artificial aids. They then sound very similar to the pure tuning-fork tones.—*Pogg. Ann. Erg.*, viii, II, 177; *Nature*, xv, 441. E. C. P.

10. *Ultra Red Spectrum.*—M. E. BECQUEREL has studied the invisible red rays of the spectrum by the aid of phosphorescence. The light is admitted into a darkened room through two slits, so that one beam shall fall on a bisulphide of carbon prism, and form the spectrum which is to be examined. The second beam passes through a prism of flint glass which is so turned that the ultra violet portion of its spectrum shall fall on the ultra red portion of the other spectrum. The flint glass spectrum is not focussed on the screen, or the slit is opened wide, so that the ultra violet lines and bands shall not be visible. These spectra are received on a plane surface covered with some phosphorescent substance. The phosphorescent hexagonal blende is best suited to this purpose, as it is strongly luminous, though it loses this effect more rapidly than the sulphides of the alcaline earths, but less rapidly than carbonate of lime. Bands are then observed beyond A for a distance somewhat greater than that from A to D. Two bands are found near A which M. Becquerel has called A_1 and A_2; then follow a group of four bands or lines A', A'_1, A'_2, A'_3, of which the first three are nearly equidistant. The wave length of A' is 840, that of A being taken as 761·5. Beyond is a broad diffuse band A'' and near the limit of vision is A''' a large band with well marked borders, especially on its more refrangible side. The wave lengths of its two edges are 1220 and 1310. Since the light of a diffraction spectrum was too small, the wave-lengths were

determined by interposing an apparatus giving colored rings by means of thin layers of air. Attempts have been made, as yet without success, to form a phosphorescent eye-piece like the fluorescent eye-piece of Mr. Soret.—*Bib. Univ.*, ccxxviii, 306.

E. C. P.

11. *Fluorescence.*—M. LOMMEL, continuing his researches on fluorescence, arrives at the following conclusions:—1. There are two kinds of fluorescence. In one, each homogeneous ray falling within the limits of the fluorescence spectrum excites not only rays of greater and equal, but also waves of shorter wave-length; the latter, so far as they belong to the region in question. In the second kind each homogeneous ray excites only rays of greater or equal wave-length. 2. There are substances which have only the first kind of fluorescence; each excitant ray excites the whole fluorescence spectrum. Hence they are not subject to Stokes's law. Such are napthalin, red chlorophyll and eosin. 3. There are substances which have only the second kind of fluorescence, and which therefore throughout their fluorescence spectrum, obey Stokes's law. Such are most of the fluorescent substances hitherto examined. 4. There are substances which have both kinds of fluorescence, so that the first kind is proper to a certain portion of their fluorescence spectrum, and the second kind proper to their remaining parts. Hence these obey Stokes's law only in part. Such are chamdelin red, blue and green.—*Pogg. Ann.*, clix, 514; *Nature*, xv, 441. E. C. P.

12. *On the Equilibrium of heterogeneous substances;* by J. WILLARD GIBBS, of Yale College. 141 pp. 8vo.—The paper on this subject by Professor Gibbs, published in volume iii. of the Transactions of the Connecticut Academy of Sciences (1876), received the following exposition by Professor J. Clerk-Maxwell, of Cambridge, England, in his lecture on the occasion of the recent Loan Exhibition:

"The thermodynamical problem of the equilibrium of heterogeneous substances was attacked by Kirchhoff in 1855, when the science was yet in its infancy, and his method has been lately followed by C. Neumann. But the methods introduced by Professor J. Willard Gibbs, of Yale College, Connecticut, seem to me to be more likely than any others to enable us, without any lengthy calculations, to comprehend the relations between the different physical and chemical states of bodies, and it is to these that I now wish to direct your attention.

In studying the properties of a homogeneous mass of fluid, consisting of n component substances, Professor Gibbs takes as his principal function the energy of the fluid, as depending on its volume and entropy together with the masses, m_1, m_2 . . . . m_n, of its n components, these $n+2$ variables being regarded as independent. Each of these variables is such that its value for any material system is the sum of its values for the different parts of the system.

By differentiating the energy with respect to each of these variables we obtain $n+2$ other quantities, each of which has a physical significance which is related to that of the variable to which it corresponds.

Thus, by differentiating with respect to the volume, we obtain the pressure of the fluid with its sign reversed; by differentiating with respect to the entropy, we obtain the temperature on the thermodynamic scale; and by differentiating with respect to the mass of any one of the component substances, we obtain what Professor Gibbs calls the potential of that substance in the mass considered.

As this conception of the potential of a substance in a given homogeneous mass is a new one, and likely to become very important in the theory of chemistry, I shall give Professor Gibbs's definition of it.

'If to any homogeneous mass we suppose an infinitesimal quantity of any substance added, the mass remaining homogeneous and its entropy and volume remaining unchanged, the increase of the energy of the mass, divided by the mass of the substance added, is the potential of that substance in the mass considered.'

These $n+2$ new quantities, the pressure, the temperature, and the n potentials of the component substances, form a class differing in kind from the first set of variables. They are not quantities capable of combination by addition, but denote the intensity of certain physical properties of the substance. Thus the pressure is the intensity of the tendency of the body to expand, the temperature is the intensity of its tendency to part with heat; and the potential of any component substance is the intensity with which it tends to expel that substance from its mass.

We may therefore distinguish these two classes of variables by calling the volume, the entropy, and the component masses the *magnitudes*, and the pressures, the temperature, and the potentials the *intensities* of the system.

The problem before us may be stated thus:—Given a homogeneous mass in a certain phase, will it remain in that phase, or will the whole or part of it pass into some other phase?

The criterion of equilibrium may be expressed thus in Professor Gibbs's words—'For the equilibrium of any isolated system it is necessary and sufficient that in all possible variations of the state of the system which do not alter its energy, the variation of its entropy shall either vanish or be negative.

'The condition may also be expressed by saying that for all possible variations of the state of the system which do not alter its entropy, the variation of its energy shall either vanish or be positive.'

Professor Gibbs has made a most important contribution to science by giving us a mathematical expression for the stability of any given phase A of matter with respect to any other phase B.

If this expression for the stability (which we may denote by the letter K) is positive, the phase A will not of itself pass into the phase B, but if it is negative the phase A will of itself pass into the phase B, unless prevented by passive resistances.

The stability K of any given phase A with respect to any other phase B, is expressed in the following form:

$$K = \varepsilon + v p - \eta t - m_1 \mu_1 - \text{etc.} - m_n \mu_n$$

where ε is the energy, v the volume, η the entropy, and m_1, m_2, etc., the components corresponding to the second phase B, while p is the pressure, t the temperature, and μ_1, μ_2, etc., the potentials corresponding to the given phase A. The intensities therefore are those belonging to the given phase A, while the magnitudes are those corresponding to the other phase B.

We may interpret this expression for the stability by saying that it is measured by the excess of the energy in the phase B, above what it would have been if the magnitudes had increased from zero to the values corresponding to the phase B, while the values of the intensities were those belonging to the phase A.

If the phase B is in all respects except that of absolute quantity of matter the same as the phase A, K is zero; but when the phase B differs from the phase A, a portion of the matter in the phase A will tend to pass into the phase B if K is negative, but not if it is zero or positive.

If the given phase A of the mass is such that the value of K is positive or zero with respect to every other phase B, then the phase A is absolutely stable, and will not of itself pass into any other phase.

If, however, K is positive with respect to all phases which differ from the phase A only by infinitesimal variations of the magnitudes, while for a certain other phase, B, in which the magnitudes differ by finite quantities from those of the phase A, K is negative, then the question whether the mass will pass from the phase A to the phase B will depend on whether it can do so without any transportation of matter through a finite distance, or, in other words, on whether matter in the phase B is or is not in contact with the mass.

In this case the phase A is stable in itself, but is liable to have its stability destroyed by contact with the smallest portion of matter in certain other phases.

Finally, if K can be made negative by any infinitesimal variations of the magnitudes of the system A, the mass will be in unstable equilibrium, and will of itself pass into some other phase.

As no such unstable phase can continue in any finite mass for any finite time, it can never become the subject of experiment; but it is of great importance in the theory of chemistry to know how these unstable phases are related to those which are relatively or absolutely stable.

The absolutely stable phases are divided from the relatively stable phases by a series of pairs of coexistent phases, for which the intensities p, t, μ, etc., are equal and K is zero. Thus water and steam at the same temperature and pressure are coexistent phases.

As one of the two coexistent phases is made to vary in a continuous manner, the other may approach it and ultimately coincide with it. The phase in which this coincidence takes place is called the Critical Phase.

The region of absolutely unstable phases is in contact with that of absolutely stable phases at the critical point. Hence, though it may be possible by preventing the body from coming in contact with certain substances to bring it into a phase far beyond the limits of absolute stability, this process cannot be indefinitely continued, for before the substance can enter a new region of stability it must pass out of the region of relative stability into one of absolute instability, when it will at once break up into a system of stable phases.

Thus in water for any given pressure there is a corresponding temperature at which it is in equilibrium with its vapor, and beyond which it cannot be raised when in contact with any gas. But if, as in the experiment of Dufour, a drop of water is carefully freed from air and entirely surrounded by liquid which has a high boiling point, it may remain in the liquid state at a temperature far above the boiling point corresponding to the pressure, though if it comes in contact with the smallest portion of any gas it instantly explodes.

But it is certain that if the temperature were raised high enough the water would enter a phase of absolutely unstable equilibrium, and that it would then explode without requiring the contact of any other substance.

Water may also be cooled below the temperature at which it generally freezes, and if the water is surrounded by another liquid of the same density the pressure may also be reduced below that of the vapor of water at that temperature. If the water when in this phase is brought in contact with ice it will freeze, but if brought in contact with a gas it will evaporate.

Professor Guthrie has recently discovered a very remarkable case of equilibrium of a liquid which may be solidified in three different ways by contact with three different substances. This is a solution of chloride of calcium in water containing 37 per cent of the salt. This solution is capable of solidification at −37° C., when it forms the solid cryohydrate having the same composition as itself. But it may be cooled somewhat below this temperature, and then if it is touched with a bit of ice it throws up ice, if it is touched with the anhydrous salt it throws down anhydrous salt, and if it is touched with the cryohydrate it solidifies into cryohydrate."

II. GEOLOGY AND MINERALOGY.

1. *The Lœss of the Rhine and Danube*, by THOMAS BELT, F.G.S.—Mr. Belt discusses the characters, position and height of the lœss, and the evidences in the transported bowlders, stones and organic remains it contains in some places, of its having originated in connection with the Glacial era, observing that "no

more Arctic fauna is known in the basin of the Danube and the Rhine than that of the lœss;" also that "along the northern flanks of the Carpatheans, the Scandinavian drift rises to heights of 1,000 to 1,200 feet." He adopts Lyell's view, that the valley had been excavated before the deposition took place. Instead of holding that the supply of water from the melting ice was sufficient to account for the height of the stream, he assumes, as in his former papers, that the ice accumulating along the coast and thus blocking up the drainage of the continents, dammed up the streams about their mouths and so caused lakes. He says, "I was first led to believe that the ice had effected this [result] in studying the glaciation of North America, and in 1866 I advanced the opinion that the drainage of the St. Lawrence had been blocked up by the ice moving down from the north; and that thus a great inland fresh-water sea had been formed over which icebergs floated. He says further that during a visit to North America in 1874, I found many more proofs that the drainage of the northeastern part of the continent was blocked by ice that flowed down the bed of the Atlantic from the direction of Greenland;" and from these and other facts, came the conclusion that "the drainage of Europe had been blocked up—not by Scandinavian ice, but by that which occupied the bed of the Atlantic and had reached to our western shores." Thus "the waters were raised over which floated icebergs from the north carrying the Scandinavian drift, and into this great lake the Danube and the Rhine, or the upper portions of them above its level, brought down fine mud from the glacier-capped Alps which was deposited as lœss."

There is no such damming, as far as is known, about Greenland, the subglacial streams being large and flowing freely to the sea; and hence the practicability of damming the fresh waters in the way supposed may be doubted. The assumed amount of Atlantic ice appears to be far beyond what could have existed. The article does not give the facts as to uniformity of level in the lœss along the whole course of the Rhine needed to prove that the deposits are of lacustrine origin. The facts about southern New England show that there has been no such damming by shore ice as Mr. Belt suggests; for they prove that the height of the terraces along the river-valleys has depended almost wholly on river-floods, with only such lakes as come from damming by ice or otherwise along their course. And it seems altogether probable that the height of the lœss on the Rhine and Danube had the same origin. The change of level proved for southern New England does not exceed fifteen feet; and none was needed to produce the occurring heights of the river-valley terraces. J. D. D.

2. *Thickness of the Palæozoic rocks of Central Pennsylvania.*—Mr. C. A. Ashburner, of the Geological Survey of Pennsylvania, has carefully measured a section of the rocks from the top of the Alleghany River Coal Series down to the Trenton limestone. The details are contained in his Report. The aggregate results are as follows: the Carboniferous from the top of the Mahoning

sandstone in the Coal Measures, to what is called the Upper Catskill or Pocono group (Rogers's Vespertine, No. 10) inclusive, at least 3,777 feet; Devonian strata, 7,975 feet; Oriskany sandstone (which is referred by some to the Devonian and others to the Upper Silurian) 58 feet; Upper Silurian 4,214 feet; Hudson River and Utica shale and Trenton at least 2,370 feet—making in all 18,394 feet.

In the section, the Pocono sandstone has a thickness of 2,133 feet, and is overlaid by the Mauch Chunk Red Shale (Rogers's Umbral), 1,100 feet; the Pottsville conglomerate (Millstone grit, Rogers's Seral), 280 feet; and the Alleghany River (or Lower Productive) Coal Measures, 264 feet. The Devonian commences with the Catskill Red sandstone (Rogers's Ponent), 2,680 feet thick, and is underlaid by 90 feet of "transition strata" between it and the next below; 1,860 feet of Chemung shales (Vergent); 1,450 feet Portage flags (Vergent); 325 feet Genesee slate (Upper Cadent); 635 feet Hamilton shales (Cadent); 875 feet Marcellus Black shale (Lower Cadent); 60 feet Upper Helderberg limestone (Post-meridian); 58 feet Oriskany sandstone (Meridian). The Upper Silurian includes 742 of Lower Helderberg beds (the upper 162 feet limestone); 440 feet of Onondaga marlytes; 1,960 feet of Clinton shales and ore-rocks (the ore-rocks 53 feet thick and including two beds of ore 12 inches apart, the upper of 10 inches average thickness and the lower of 14 inches); 1,330 feet of Medina sandstone; 568 of Oneida sandstone (Levant). The Lower Silurian includes Hudson River shale 800 feet; Utica shale 1,070 feet; Trenton limestone 500 feet. Below lie the Calciferous and Potsdam, of unknown thickness.

3. *Notes upon the Lower Helderberg rocks of Port Jervis, N. Y.*;* by Dr. S. T. Barrett.—The subdivisions and fossil contents of the Lower Helderberg and underlying rocks near this village are sufficiently peculiar to warrant their description. They are situated in the midst of what has very appropriately been called the Appalachian System; a system of long monoclinal ridges fronting the Atlantic and sloping backward with varying dips toward the northwest. These monoclinal ridges trending northeast and southwest are crossed more or less obliquely by a secondary and compensatory system of flexures trending nearly north and south. The Lower and Upper Helderberg strata together constitute, when elevated above the drift, a low monoclinal ridge extending parallel with the Shawangunk (pronounced Shongum) Mountain, at a distance varying from less than a mile to three or four miles northwest of the crest-line of that mountain. The transverse or secondary system of flexures cause the Helderberg Ridge to rise and sink in a succession of anticlinal and synclinal folds, which add very much to the picturesqueness of the long monoclinal valley in which Port Jervis is situated. The roads across this ridge are made necessarily in the synclinals,

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* Abridged by the author from a paper upon the same subject in vol. xi, Ann. Lyc. Nat. History, N. Y.

and the lime-quarries are worked in the southeastern fronts of the anticlinals. This arrangement is further deversified by the dip; the ridges and valleys being narrowest where that is steepest, and broadest where it is most nearly horizontal. These secondary flexures are very near together here, three of them occurring in the space of six miles lineally of the ridge. Bennet's Quarry is the central one of these, and has been most studied by the writer. Nearpass' and Buckley's Quarries lie south and north of it respectively. The strata visible at any quarry depends upon the extent of the upheaval, the amount of talus at bottom, and of erosion at the top.

There are at Bennet's Quarry, beginning at the bottom:

No. 1. Tentaculite Limestone, Prof. Cook's Quarry Stone;[*] makes the best of lime for building purposes; about twenty feet thick.[†]
No. 2. Favosite Limestone; from two to five feet thick.
No. 3. Lower Pentamerus and Cherty Limestone; together, forty feet thick.
No. 4. Delthyris Shale; one hundred and twenty feet thick.
No. 5. Upper Quarry Stone; ten feet thick.
No. 6. Upper Shale; one hundred and fifty feet thick.
No. 7. Trilobite Layers; five to ten feet thick.
Nos. 5, 6 and 7 are believed to belong to the Upper Pentamerus subdivision; and are succeeded by rocks of the Oriskany Sandstone and Cauda Galli Grit formations, the latter exhibiting a thickness of from five hundred to eight hundred feet.

The following fossils were very kindly identified for me by Prof. Hall:

From No. 1, Tentaculate Limestone; *Tentaculites gyracanthus*, *Spirifer Vanuxemi*, *Megambonia ovoidea*, and *Strophodonta varistriata.*

From No. 2, or Favosite Limestone, *Favosites Helderbergi*, a *Cyathophyllum*, and *Pentamerus galeatus.*

From No. 3, or Lower Pentamerus and Cherty Limestones; *Dalmanites pleuroptyx*, *Pentamerus galeatus*, and a form of *Lichenalia.*

From No. 4, Delthyris Shale; *Spirifer macropleurus*, *S. lamellosus*, and many more forms peculiar to and usually abundant in this subdivision.

From No. 5, Upper Quarry Stone; *Rhynchonella ventricosa* and *Platyceras retrorsum.*

From No. 6, Upper Shale. This subdivision is very sparingly fossiliferous.

From No. 7, Trilobite layers; *Chonetes complanata*, *Rensselaeria mutabilis*, *Homalonotus Vanuxemi*, *Dalmanites pleuroptyx*, *D. nasuta*, *D. micrurus*,[‡] *D. dentata*, *Hyolithes centennialis*, *Strophomena rhomboidalis*, *S. Conradi*, *Strophodonta cavumbona*, *S. planulata*, *S. Beckii*, *S. Leavenworthana*, *S. varistriata*,

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[*] Geology of New Jersey, p. 159.

[†] The thickness of strata as given in this paper, and the names of subdivisions are different from the original paper. I think the thickness was overestimated in my first.

[‡] Described by myself in this Journal, vol. xi, p. 200. Described by me in Ann. Lyc. Nat. Hist. N. Y.. vol. xi.

his subcarinata, *O. multistriata*, *Spirifer arrectus*, *Cyrtia ross-*
a, *Pterinea textilis*, *Discina discus*, *D. Conradi*, *Holopea anti-*
, *Loxonema Fitchiana*, *Tentaculites elongatus*, a form allied to
matis, a *Beyrichia*, probably *B. granulifera*, and some other
cies not determined.

have been thus exhaustive in the enumeration of the species
tained in this subdivision, because the richness of its fauna,
arated as it is by more than a hundred feet of nearly unfossil-
ous strata from the true Delthyris Shale below, and the num-
of species apparently unknown elsewhere, make it one of the
malies in the geology of the locality. The most abundant fos-
, and in the order named, are *Chonetes complanata*, *Renssel-*
ia mutabilis, and *Dalmanites dentata*. The stony casts of these
sils literally make up the rock.

The Favosite Limestone,* No. 2, is also peculiar. It is so full
large corals, principally Favosites, that it is at first hard to
ieve it is not the equivalent of the Coralline of Schoharie,
scribed by Prof. Hall in his Palæozoic Fossils of New York,
lume ii. It occupies, however, about the position assigned by
t distinguished paleontologist to the Stromatopora limestone.
is a coarse, brecciated limestone, and contains, besides Favo-
es, an abundance of encrinal fragments in an unrecognizable
dition, *Chætetes Helderbergia*, *Pentamerus galeatus*, *Stropho-*
nta punctulifera, and other Delthyris Shale fossils. *Favosites*
lderbergia is certainly present, but unless that species is very
riable, it is not the only form of the genus so numerously rep-
ented in this layer. The most common type resembles very
sely the *F. Niagarensis* of Hall. Although this Favosite
mestone is very distinct from the Coralline of Schoharie, the
sence of *F. Niagarensis* in the former, if it is present, would
m to make that fossil of little account in determining the age
the latter limestone.

4. *Geological and Geographical Survey of the Territories*, F.
HAYDEN, U. S. Geologist-in-charge.—The Survey has recently
ued a "Drainage Map" of Colorado; the primary triangula-
n by J. T. GARDNER and A. D. WILSON, the topography by A.
WILSON, G. R. BECHLER, H. GANNETT, G. B. CHITTENDEN, and
B. LADD. Also a Hypsometric Map of the United States, by
ENRY GANNETT, M.E., a map of contour lines, which includes the
ole of the United States, and gives, far better than any map
therto published, the topography of this part of the continent.
r. Gannett, besides being an engineer himself, is the author of
e Report, from this Survey, containing full lists of all heights
at have been determined in the country, and he was thus pre-
red for making this diagram of the collected facts. Such a map
of course and always will be capable of improvement. But it
ings out well the great features of the mountain region west
the Mississippi. The contour lines are those of 500 and 1,000
et, and of each added 1,000.

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* Name suggested by Prof. D. S. Martin, of Rutgers Female College, N. Y.

A new number of the *Bulletin of the Survey* contains a paper entitled "a Calendar of the Dakota Nation"—a document of pictorial hieroglyphics, comprising the chief events in Dakota history, during the 71 years following 1799, with its interpretation, by Lieut.-Col. G. Mallery; also others—on the Kjökkenmöddings and graves of a former population of the coast of Oregon, by P. Schumacher, with 22 maps and plates; on the Twana Indians of the Skokomish Reservation in Washington Territory, by Rev. M. Eells; Notes on a Collection of Noctuid Moths, made in Colorado in 1875 by Dr. A. S. Packard, Jr., by A. R. Grote; on the Tineina of Colorado, and on new Entomostracans from Colorado, by V. T. Chambers; on a new Cave Fauna in Utah, and descriptions of new Phyllopod Crustacea from the West collected by Dr. T. Watson and Dr. E. Coues, by Dr. A. S. Packard, Jr.; Notes on some Artesian borings along the line of the Union Pacific Railroad in Wyoming Territory, by F. V. Hayden.

These Artesian borings, seven in number, are located between Rawlins and Green River, and were made by the chief engineer of the Pacific Railroad, Mr. T. E. Sickles. The surface varies in height from 6,224 to 7,100 feet—the latter on the "Continental divide." The beds passed through were Tertiary or Tertiary and Cretaceous, and lie in a basin, very nearly horizontal. No. 1 counting from the west, near Rock Springs, 1,145 feet deep, stopped at the bottom of the Fox Hill group of the Cretaceous, and afforded a flow at the surface of 960 gallons per hour, or 26 feet above it of 570 gallons per hour. No. 2, near Point of Rocks, 1,000 feet deep, stopped at the top of the Fox Hill group, and afforded an abundant supply of water at 17 feet from surface. No. 3, near Bitter Creek, 696 feet deep, descended into the Laramie group, the upper part of the Lignitic series, "and yields 2,160 gallons per hour, while flowing 1,000 gallons per hour. The most western, just east of Creston, 1,105 feet deep, reached to the bottom of the Cretaceous, and yields 2,000 gallons of water per hour; water ten feet from the surface."

5. *Note on the Criticism of Prof. Stevenson;* by A. C. Peale. (Communicated).—The only point in Prof. Stevenson's criticism of my notes on the age of the Rocky Mountains in Colorado,* which requires an answer is as follows:

On page 298 he says that on page 174 of my article "the statement is made that the Trias is present in Southwestern Colorado and Northern New Mexico," and that I use its presence there as a strong proof of its presence in the interior in opposition to his assertion that it is absent in the interior. To prevent misapprehension I wish to state that the sentence on page 174 of my article reads as follows: "In Southwestern Colorado and Northern New Mexico, the Triassic is *also* present." On pages 173 and 174 I prove its presence in the interior (i. e. in South Park, north and west of the Sawatch Range, and in the Elk Mountains). Hence I do not use its presence in Southwestern Colorado and Northern New Mexico as a proof of its presence in the interior.

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* This volume, page 291.

The main points of my article are not touched by Prof. Stevenson, except one, viz: in regard to the Tertiary elevation of the Rocky Mountains, in which, as he says, we agree. As to his Carboniferous and Triassic upheavals we differ.

It is my intention to elaborate my views on the subject in the Report of the Survey for 1876.

Washington, D. C., April 18th, 1877.

6. *American Palæozoic Fossils.*—Mr. S. A. Miller of Cincinnati, Ohio, proposes to publish a catalogue of the species of American Palæozoic fossils arranged under each class in alphabetical order, giving name of author, date and place of publication, stratigraphical position, and etymology of words. The prospectus states that the volume will contain about 275 pages, and will be ready for sale by the 1st of June next. Price, bound in cloth, $3.00. Mr. Miller should be addressed at No. 8 W. 3d street, Cincinnati, Ohio.

7. *Palæontographica. Beiträge zur Naturgeschichte der Vorzeit, herausgegeben* von W. Dunker (of Marburg) und K. A. Zittel (of Munich).—It is proposed to issue the Palæontographica hereafter annually in volumes like the earlier, at a price not exceeding 45 shillings (English) per year, payable at the beginning of each year by Post Office order. The editors will have the assistance of W. Benecke, E. Beyrich, M. Neumayr, F. Römer, and K. von Seebach, as a committee of the German Geological Society. The 20 volumes of the first series, and 1 to 3 of the second, may now be had at 50 per cent deduction from the original prices, if applied for at once. The publisher is Theodore Fisher of Cassel, Prussia.

8. *Analyses of Japanese Porcelain-rocks*, by Henry Wurtz.—The paper upon porcelains and porcelain-rocks from Japan, by Mr. Wurtz, was noticed in the last number of this Journal (p. 320). The following are some of the analyses contained in the paper:—Analysis (1) is of a variety which has the native name *Tsuji-chuchi;* it is one of the most valuable of the porcelain-rocks found at Idzumiyama. It is a dull-white, porous, granular, coherent mass, not unlike coarse chalk in appearance, though much tougher. It adheres to the tongue, with a chalky taste. Several other varieties of somewhat different appearance, and employed in different ways in the manufacture of the porcelain, gave very nearly the same composition. This is shown in the analysis (2) of the variety Shiro-chuchi.

The only one which varies widely from these in chemical character is the kind called Kudaru-yama-chuchi, and for which Mr. Wurtz coins the English name, *Kudaruyamite.* Analysis (3) below gives its composition (G.=2·653), and (4) the same after the deduction of the opal-silica present. It is a pure white, soft, chalk-like substance, with slightly unctuous feel; under a magnifier it appears to be made up of small, amorphous, transparent grains. In water it falls to powder immediately.

	SiO_2	AlO_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	
1.	78·18	15·70	·66	tr.	·10	--	1·74	·55	2·52=	99·45
2.	77·68	15·19	·89	·01	·10	·15	1·47	·51	3·33=	99·33
3.	49·93	38·74	1·58	--	·21	--	1·44	·44	7·61=	99·95
4.	47·95	40·82	1·67				1·77		7·79=	100·00

9. *On the Hermannolite of Shepard, and on the Samarskite of North Carolina*; by Prof. Delafontaine. (Letter to J. D. Dana, dated Chicago, March 23, 1877.)—I have recently made an examination of some tantaliferous minerals of the United States, a brief account of which I offer now. Prof. Shepard sent me last summer a sample of his *hermannolite*, in which I was able to find only a large proportion of niobic acid, about 16 per cent of tantalic acid, and very doubtfully a little titanic acid. In one of his notes on this subject Prof. Shepard insists upon the difference in specific gravity between hermannolite and the niobite (columbite) from Brainard's. Two facts account for that: Brainard's niobite contains over 37 per cent of tantalic acid, as I ascertained from specimens kindly given to me by Mr. C. U. Shepard himself; furthermore, the crystals of hermannolite contain some foreign substance in the form of yellowish crystals, which I could not separate from the mass they were imbedded in.

In the Portland and Middletown (Conn.) columbites I found respectively 22·6 and 20 per cent of tantalic acid. A careful examination of the samarskite from Mitchell County (N. C.) has shown me that the brownish variety, with a less conchoidal fracture, looking somewhat like euxenite, contains about 25 per cent of *tantalic acid*, a small percentage of *thoria* and of *didymium*, in addition to the elements found by Hunt in 1852. The yttria includes also a little of the rosy earth with absorption spectrum, called *erbia* by Bunsen, Cleve and others, and more of the yellow earth described by Mosander under the name of *erbia*, but which, in order to avoid confusion, I call *terbia* (giving up the name *mosandria* which I proposed three years ago). The existence of that base is still denied by Bunsen and Cleve, but their conclusions I am further than ever from accepting. A monograph of its principal compounds will soon be published. All my endeavors to find Mr. Hermann's *ilmenium* in samarskite have proved unsuccessful as well as those of Marignac and Blomstrand, working on other material.

[The account by Prof. Shepard states that the hermannolite was found at a locality near the house of Mr. Cook (a dealer in minerals); but Mr. Cook informs us that there is no such locality, and that it must have come from the columbite locality, a mile distant from it.—Eds.]

III. BOTANY AND ZOOLOGY.

1. *On Right-handed and Left-handed Relations in Space.*—The following is extracted from J. Clerk-Maxwell's Treatise on Electricity and Magnetism, i, p. 23. "In this treatise, the motions of translation along any axis, and of rotation around that axis, will be assumed to be of the same sign, when their directions correspond to those of an ordinary or right-handed screw." "The combined action of the muscles of the arm when we turn the upper side of the right hand outward, and at the same time thrust the hand forward, will impress the right-handed screw motion on the memory more firmly than any verbal definition. A common corkscrew may be used as a material symbol of the same relation." "This is the right-handed system which is adopted in Thomson and Tait's *Natural Philosophy*, § 243. The opposite, or left-handed system, is adopted in Hamilton and Tait's *Quaternions*."

It appears, therefore, that the view which "A. Gray, Darwin, and Bentham" are blamed for taking, is regarded as the natural one by Clerk Maxwell, Thomson, etc., among the mathematicians and physicists. For avoiding ambiguity, "Prof. W. H. Miller has suggested to me that, as the tendrils of the vine are right-handed screws, and those of the hop left-handed, the two systems of relations in space might be called those of the vine and hop respectively," Maxwell, l. c. This botanical illustration is readily understood, but is not altogether a happy one. By "the vine," everywhere out of the United States, the grape-vine (as we call it) is meant. Now the vine-tendril hardly coils except when it has laid held, and then, when half the coil is in one direction the other is necessarily in the reverse. And the hop has no tendrils: the meaning is that its *stem* in climbing moves from *right to left*, i. e., of the outside observer; while in the larger number of climbers (of which Bindweed, *Convolvulus*, etc., is the better type) the movement is in the opposite direction. But the terms "hop-system and vine-system" are obviously impracticable in descriptive botany. "With the sun" and "against the sun"—the terms which Darwin commonly uses—might perhaps be made manageable in botanical description; but the term heliotropic is used in a different sense and connection, and anti-heliotropic for the counterpart is too long and awkward a word. *Eutropic* and *antitropic* might serve the purpose, and if agreed upon would do away with the ambiguity of the terms right and left, as affected by the position of the observer, whether within or without the circle or coil. Thus, in saying that the hop in twining "follows the course of the sun," it matters not whether the coil and the apparent path of the sun be regarded from the outside or from the inside. A. G.

2. *Observations sur l'enroulement des Vrilles*, par M. CASIMIR DECANDOLLE. Extr. Archiv. des Sciences de la Bibliotèque Universelle. Jan., 1877. pp. 13.—The double turn of the helix in attached tendrils excited the author's attention, but he finds, as

would be expected, that this is a purely mechanical result and a necessity of the situation. He neatly demonstrates this, by allowing a tendril to seize by its free tip some solid object suspended from a thread, the torsion which takes the place of the inverse turns of the coil in the ordinary situation. The lower side of the tendril is always interior in the coil. This comes from the arrangement of its fibrous bundles, which form a circle only at the base of the tendril, but above this only an arc, open on the upper side; this upper cellular portion is accordingly more affected by turgescence and can grow longer than the lower. Tendrils which remain free are less vigorous than those which gain attachment; vigor, as well as increased growth in thickness, is developed by use. The difference in the direction of the coiling, whether from right to left or left to right (or as we should like to say, whether *eutropic* or *antitropic*) does not depend upon anything in their anatomical structure, but appears to be in some way determined by the plant. A series of experiments with detached tendrils floated on water, or with the cut end immersed, and with tendrils divided into pieces (which preserve their vitality and continue their action) show this; when fixed by one end and free at the other, or at least when fixed by the summit only, they coil nearly as often in one direction as the other. The elongation of the different portions of a tendril ceases first at the base; it regularly augments from base to apex. A. G.

3. *Date of the parts of Elliott's Botany.*—Referring to our note in the January No. of this Journal, it is worth recording that the first fasciculus actually ended, as was supposed, on p. 96. No. 5 consisted of pages 401 to 496, and bears the date of 1817. No. 6 contained pages 497 to 606, and is dated 1821. This information is obtained from the inspection of copies of those parts in their original state, and is obligingly supplied by Mr. F. B. Dexter, of the Yale College Library. A. G.

4. *Onion-Smut*, by Prof. W. G. FARLOW.—A pamphlet of 15 pages, with a plate, extracted from the 24th Annual Report of the Secretary of the Massachusetts State Board of Agriculture, Boston, 1877.—The smut in question is as yet unknown out of New England, and there it has not long been known; but of late it has done much damage to the onion-crop at Wethersfield, Conn., and in Essex Co., Mass. The fungus proves to be a peculiar species of the *Ustilagineæ*, to which that of Indian Corn (*Ustilago Mayidis*) and of Rye, etc., belong. This onion-smut is most like that of Rye, *Urocystis occulta*, and a figure of an affected rye-stalk is given in this paper along with that of the onion. The fungus of the latter was named, by Mr. Frost of Brattleboro, *Urocystis Cepulæ;* but it is now for the first time described and illustrated by Prof. Farlow. The subject had, however, been taken up by "the microscopist of the Agricultural Department at Washington," in the Report of 1872; but Prof. Farlow intimates—what we should have expected—that the account and figures there given throw no light upon the matter. The remedy suggested is to burn over the fields where the smut has appeared, and not to raise onions

upon it again for three or four years at least. The smut is thought unlikely to be conveyed or introduced with onion-seed. A. G.

5. *Botanical Instruction at Harvard University.*—In the course of summer instruction in science for 1877 (which commences July 6) both botanical courses are to be given at Cambridge. Formerly, while Prof. Goodale's instruction in Phænogamic Botany was given at the Botanic Garden, that on Cryptogamic Botany, by Prof. Farlow, was given at the sea-side. This is now to be given at Cambridge, whence collecting excursions can readily be made to good points on the shore. As it may be useful to call particular attention to this unique opportunity of obtaining a knowledge of the lower Cryptogamia, we copy the portion of the general circular which relates to Prof. Farlow's course. Prof. Goodale's course on Phænogamic Botany is already well known. But those who seek information respecting it should apply for the circular issued by the University.

"*Cryptogamic Botany.* The course will begin on Friday morning, July 6th, and continue six weeks. Microscopes and all necessary equipments are provided by the University, but students are expected to bring sharp razors, razor strops, dissecting needles, slides, and covering-glasses. No provision, however, is made for drying and preparing specimens other than microscopic. A knowledge of the rudiments of Phænogamic Botany is required of those taking this course, or in case of those wishing to pursue the subject in connection with Zoological studies, a practical acquaintance with the working of the compound microscope. A general course of lectures will be given upon the structure and development of Thallogens, and on one day of the week an excursion will be made either into the country or to the sea-shore.

Laboratory instruction will be given every day except Saturday, and the method of examining Fungi and Algæ and the manner of making microscopic preparations will be taught. Illustrations of the structure, and, as far as time will allow, of the development of the principal orders of Fungi and Algæ will be afforded each student, and an opportunity will be given to become familiar with the more common moulds, blights, and with a few agarics. Students who have attended a previous course can pursue more in detail any branch of the subject they may prefer. Under certain restrictions, students may consult the extensive cryptogamic collections and library of the University."

We believe that the announcement may now be made that Prof. Farlow's instruction in Cryptogamic Botany in the University proper, will hereafter be given at Cambridge, instead of at the Bussey Institution at Jamaica Plain, a change greatly to the convenience and advantage of the students which this important course of study is likely to attract. Dr. Farlow was a pupil of De Bary and of the late M. Thuret. With the facilities now afforded, he should establish the school of Cryptogamic Botany in this country which has long been needed.

At the Bussey Institution it is expected that a very full elementary course of instruction on Botany and Vegetable Physiology, in relation to rural affairs, horticulture, agriculture, etc., will be given throughout the year, by lectures and laboratory-teaching. This course will be conducted by Profs. Goodale, Farlow, and others.

6. *Classification and Terminology in Monocotyledons*, by GEORGE BENTHAM.—A paper of 30 pages, and with three plates, closing the 15th volume of the Journal of the Linnean Society, 1877. An arrangement of the orders is sketched, which, being employed in the *Flora Australiensis*, will doubtless be adopted in the new *Genera Plantarum*, unless in the mean while reason appears for modifying it. They are grouped in four alliances, or cohorts, beginning with those bearing the most complete and differentiated flowers, thus: Alliance 1, EPIGYNÆ, with inferior ovary and mostly biseriate perianth. The four sections are based upon habit and the seeds, in which rather more than usual rests upon the presence or absence of albumen. *Hydrocharideæ*, aquatic plants, with regular flowers and exalbuminous seeds, begin the series. The *Scitamineæ*, which follow, by an awkward misprint or slip, are said to have *ex*-albuminous seeds. As they really accord in this regard with the fourth and larger section which begins with the *Irideæ* and ends with the *Bromeliaceæ*, they might as well be placed after the third section, which consists of the *Orchideæ* and *Burmanniaceæ*.

Alliance 2, CORONARIÆ, with superior mostly syncarpous ovary, albuminous seeds and mostly biseriate perianth. Its first section, with perianth of both series petaloid [a character not without exception], consists of the *Liliaceæ* and their allies, down to the *Pontederiaceæ*. In the list of suborders of *Liliaceæ* "Agaveæ" has by accident been printed instead of *Aloineæ*. A second group has the outer perianth calycine or none, and the inner petaloid; *Philydraceæ*, *Xyrideæ*, *Commelynaceæ* (but not *Trillium*). The third group has perianth of both series calycine, and includes the *Junceæ* and *Palmæ*.

Alliance 3, NUDIFLORÆ, with free ovary apocarpous, monocarpellary, or rarely syncarpous; the perianth either none or reduced to a scale under each anther. *Alismaceæ* are exceptional; but their association with *Aroideæ* and *Naiadaceæ* seems natural.

Alliance 4, GLUMALES, contains two groups; the first with ovary often more than one-celled, and ovule pendulous; *Eriocauloneæ*, *Centrolepideæ*, *Restiaceæ*. The second, with one-celled ovary and erect ovule, *Cyperaceæ*, *Gramineæ*. The schedule is followed by a series of critical remarks and explanations.

The homology of the parts of the blossom in *Xyris* is reviewed, and better interpreted; the two outer so-called perianth-segments are shown to be bractlets; what was taken for a third segment, within the two outer, is shown to be the representative of the whole exterior perianth, mostly caducous; as to the remaining or tubular perianth no conflict has arisen.

The chief interest of the latter part of this paper is found in the exposition of the homology and terminology of glumes, etc., in *Cyperaceæ* and *Gramineæ*,—a just account of which can hardly be given in a brief abstract. Mr. Bentham prefers to use the term glume in *Cyperaceæ* as well as in Grasses. While highly approving the systematic labors of Boeckeler, of Berlin, in the former order, he criticises some parts of his terminology and morphology. Mr. Bentham's own conclusions correspond with those adopted in this country as to the structure in *Cyperaceæ*. As to *Gramineæ* our prepossessions were all in favor of Robert Brown's view, adopted by Kunth and most agrostologists, so that little attention was paid to the view proposed in our author's Handbook of the British Flora. We have not room here to exhibit the proposed view and the aptly-stated reasons for its adoption. Suffice it to say that we are convinced by the latter, and that the adoption of this view will simplify the study of Grasses, and bring the homology of the gramineous spikelet into full accordance with that of *Cyperaceæ* and other orders. The exposition given is certainly well calculated "to enforce a principle generally admitted, but unfortunately too much neglected by speculative botanists, viz: that to be really useful, descriptions should, in clear and intelligible language, not only enable the reader to identify the plant he has in hand, but call his attention specially to those characters which may indicate its real affinities, the homologies of its parts, and any other relations they may have. But for this purpose it is necessary that the author should distinguish descriptions of plants from theoretical explanations, that he should, in terms the most capable of strict definition, describe only what the observer may actually see, not what it may be theoretically imagined he ought to see, reserving his theories for comments upon what has actually been observed." A. G.

7. *The Various Contrivances by which Orchids are fertilized by Insects;* by CHARLES DARWIN. Second edition. New York.—The first edition of this interesting work, which appeared in 1862, was reviewed at that time in this Journal, and served as the basis upon which to display the curious adaptations of some of our North American Orchises. This second edition, to which much is added, has been reprinted by D. Appleton & Co. of New York, and so our botanists will soon be familiar with it. In a future number we propose to give some account of the volume, along with a forthcoming one upon a cognate subject by the same author. A. G.

IV. ASTRONOMY.

1. *The New Star in Cygnus.*—A remarkable stellar outburst, similar to that which appeared in *Corona Borealis* in May, 1866, was first noticed by Dr. Schmidt, at Athens, on the 24th of November last, at 5.41 P. M., in the constellation *Cygnus*, then near the zenith. The new star, when first observed, was of the third magnitude, and of a yellow color, near ρ *Cygni*, where Dr. Schmidt is sure that no corresponding object existed on the evening of November 20. The sky was overcast at Athens on the three following days, and most probably the outburst appeared at

its full brilliancy in the interval between November 20 and 24. At midnight on the latter day the light of the star was of greater intensity than that of *η Pegasi*, noted of the third magnitude by Argelander. Its position does not appear to be recorded in the usual catalogues of small stars; certainly not in those of Lalande, Weisse's Bessel, Bode, D'Agelet, or in the Durchmusterung of Argelander. From an observation made by Mr. Hind at Mr. Bishop's Observatory on December 13, its R.A. for 1876·0 is 21^{h} 36^{m} $50^{s}\cdot41$, and its N.P.D. 47° 43′ 21″·5.

Unfortunately, Dr. Schmidt's discovery was not immediately communicated to the Astronomer-Royal or to any other English astronomer, although a telegram was sent to Dr. Littrow, at Vienna, and probably to other Continental observers. The first information of the sudden appearance of the new star was received in England only in the second week in December, from the public notices inserted in the Bulletin International and Comptes Rendus. This neglect is much to be regretted, as there were eight favorable evenings at Greenwich before December 9, when spectroscopic observations might have been successfully made, and of these at least two were near the time of the star's maximum brilliancy. Principally for this reason, but also in consequence of almost continuous unfavorable weather afterward, very few observations of the star have been made in this country. When seen by Mr. Hind on December 13, it had receded to the sixth magnitude, and was without a trace of color. The observers in Paris were more fortunate in obtaining information, for the star was examined on December 2, during a brief interval of clear sky, by MM. Henry, Cornu, and Cazin, and estimated of the fifth magnitude. Under more favorable circumstances, on December 4, M. Cornu made some satisfactory observations of the spectrum of the star with the eastern equatoreal of the Paris Observatory, the magnitude on that day being estimated at 4·5. The spectrum exhibited eight detached bright lines on a luminous ground, with an almost complete interruption of the light between the green and the indigo M. Cornu saw no dark lines; if they had existed they must have been very fine, and invisible owing to the faintness of the light.

Naming the bright lines according to their intensity by the Greek letters α to θ, their positions in the spectrum, in relation to those of certain elements, may be readily seen from the numbers in the following table determined by M. Cornu:—

	α	*δ*	*γ*	*β*	*ζ*	*η*	*θ*	*ε*
Observed	661	588	531	517	500	483	451	435
Hydrogen........	656 (C)	---	---	---	---	486 (F)	---	434
Sodium	---	589 (D)	---	---	---	---	---	---
Magnesium	---	---	---	517 (*b* mean)	---	---	---	---
Coronal line	---	---	532	---	---	---	---	---
Chromosphere lines	---	587	---	---	---	---	447	---

M. Cornu remarks as an interesting fact, but one requiring confirmation, that there are several coincidences shown in the preceding table which have led him to the conclusion that the bright in the star-spectrum correspond exclusively with the princi- nes in that of the chromosphere, and therefore that the light e star possesses precisely the same composition as that of the envelope. He says: "But the most curious result, which I here with much reserve, but which it will be very interesting wards to verify, is the coincidence of the line γ, very bright e spectrum of the star, with the green line $\lambda = 532$ (1474 of ıhoff's scale), observed in the spectrum of the Solar corona n the chromosphere; the feeble band θ corresponds also with ıd $\lambda = 447$ of the chromosphere; one is thus led to think that ine ζ corresponds rather with the bright line of the chromo- e $\lambda = 587$ (helium), than with that of sodium, 589. If this pretation be correct, the bright lines of the spectrum of the comprehend exclusively the brightest and the most frequent of the chromosphere."

e spectrum of the star has also been examined by Father ii, Dr. Vogel, and others, all of whom confirm generally the ous observations of M. Cornu. Several bright lines were by Dr. Vogel in the red, blue-green, and blue parts of the rum; bright bands were also visible in the yellow and green; hese may possibly be portions of a continuous spectrum seen ıt by contrast with absorption bands, of which there were as r as eight or ten. The blue and violet were brighter than in stars with band spectra. The bright lines C, F, and D_3 were le; *b*, however, was probably not seen bright, but a bright ɔn the blue side was noticed, which may possibly be identical a line which under peculiar circumstances is the brightest in pectrum of hydrocarbon. One seen in the violet may be the line of hydrogen. Dr. Vogel remarks that there are three stars in *Cygnus* giving quite unique spectra.

careful comparisons with several neighboring stars, Dr. ıidt noted the gradual diminution in the intensity of the light e star almost daily. The variations of magnitude are ex- ed in the following table:—

ovember	24	3·0	Magnitude.	December	5	5·9	Magnitude.
"	25	3·1	"	"	7	6·3	"
"	26	3·1	"	"	8	6·5	"
"	27	3·2	"	"	9	6·6	"
"	28	3·8	"	"	10	6·5	"
"	29	4·7	"	"	11	6·7	"
"	30	5·0	"	"	12	6·7	"
ecember	1	5·2	"	"	13	6·8	"
"	2	5·4	"	"	14	6·9	"
"	3	5·6	"	"	15	7·0	"
"	4	5·8	"				

the end of the year the star was still about the seventh ıitude, and of a decidedly orange color, with a reddish tint. *nthly Notices Astron. Soc.*, Feb., 1877.

Planets recently discovered.—The names, orbits, times of very, and names of discoverers of the minor planets found the beginning of 1876, are given in the following table. orbits are from the circulars to the Berliner Jahrbuch.

PLANETS RECENTLY DISCOVERED.

No.	Name.	Time of Discovery.	Discoverer.	Mean Dist.	Angle of Eccent.		Incl.		Long. of Node.		Long. Per.	
					°	′	°	′	°	′	°	′
158	Coronis,	Jan. 4, 1876	Knorre	2·9901	16	59	1	23	282	49	355	10
159	Æmilia,	Jan. 26, "	Paul Henry.	3·1253	6	38	6	5	135	5	100	40
160	Una,	Feb. 20, "	Peters.	2·7542	3	39	3	32	12	3	191	16
161	Athor,	Apr. 16, "	Watson.	2·3760	7	38	9	10	18	33	312	56
162	Laurentia,	Apr. 21, "	Pros. Henry.	3·0211	9	31	6	3	38	15	147	44
163	Erigone,	Apr. 26, "	Perrotin.	2·3507	8	34	4	41	159	0	93	17
164	Eva,	July 12, "	Paul Henry.	2·5525	18	42	24	48	77	27	2	46
165	Loreley,	Aug. 9, "	Peters.	3·1286	4	10	11	10	304	1	282	24
166	Rhodope,	Aug. 15, "	Peters.	2·7199	13	48	11	41	129	15	30	52
167	Urda,	Aug. 28, "	Peters.	3·2186	18	11	1	42	170	7	32	39
168	Sibylla,	Sept. 28, "	Watson.	3·3781	3	51	4	35	209	36	5	43
169	Zelia,	" "	Pros. Henry.	2·3580	7	30	5	31	354	35	326	35
170		Jan. 10, 1877.	Perrotin.	2·5510	3	44	14	21	301	18	98	37
171		Jan. 13, "	Borrelly.	3·1472	8	8	2	30	100	54	151	21
172		Feb. 5, "	Borrelly.	2·3795	5	46	9	41	331	48	326	17

To the planet (150) the name *Nuwa* has been given. The observations of (149) *Medusæ* and (155) *Scylla* were not such as to furnish reliable elements of their orbits.

To the planets recently discovered might be added the two rediscovered by Palissa, viz: (66) *Maia*, (Sept., 1876,) not seen before since 1861, the time of its discovery by Tuttle, and (107) *Camilla*, (March, 1877,) not seen before since 1868, when discovered by Pogson. Of the first 140 planets between Mars and Jupiter, the following have been seen only at the opposition near the time of discovery, viz: (99) *Dike*, (125) *Liberatrix*, (132) *Aethra*, (137) *Meliboca* and (139) *Jueica*. The following have been observed at one opposition subsequent to the time of discovery, viz: (66) *Maia*, (104) *Clymene*, (107) *Camilla*, (123) *Brunhilda*, (131) *Vala*, (133) *Cyrene*, (134) *Sophrosyne*, and (135) *Hertha*. Seven others of the 140 have been observed at two oppositions subsequent to that of discovery, and 120 at four or more oppositions including that of discovery. H. A. N.

3. *Publications of the Private Observatory of Lord Lindsay, Dun Echt (Aberdeen).*—Vol. i, of this series has just been issued in quarto form. It is privately (and extremely well) printed and has been liberally distributed to astronomers in Europe and America. Its title page well describes its contents:—"A Summary or index of the measurements (of double stars) in the 'stellarum duplicium et multiplicium mensuræ micrometricæ,' F. G. W. Struve, 1837, and 'Additamentum in F. G. W. Struve mensuras micrometricas stellarum duplicium' (1837), including all the stars in the 'Synopsis observationum de stellis duplicibus, in specula Dorpatensi, annis a 1814 ad 1824, per instrumenta minora perfectum' and in the 'II. mensuræ micrometricæ'—reärranged in order of R. A., and the positions brought up to 1875."

Each page contains thirteen columns and everything relating to each star is found in its horizontal line or in a foot note. Column 1 contains Struve's number, column 2 the page in *Mens. Mic.*

where the star is to be found, column 3 the synonyms, columns 4 and 5 the R. A. and δ for 1875·0, column 6 the lowest and highest magnifying powers used by Struve, column 7 the mean date of observation, columns 8 and 9 Struve's distance and position angle, columns 10 and 11 give the magnitude and color of the principal component A, columns 12 and 13 the same data for B. Appended is a table of the precessions in declination for *ten years* and a diagram from which the variable part of the precession in R. A. for *ten years* in minutes of time can be taken by inspection. Double star observers will find this a most useful and valuable work. E. S. H.

4. *La Luce Zodiacale, sue Leggi e Teoria Cosmico-Atmosferica, dedotte dalle Osservazione di G. Jones*, per il P. A. SERPIERI, D. S. P., Direttore dell' Osservatorio Meteorologico di Urbino. Palermo, 1876. 4to, pp. vi, 113, with 4 plates.—This is a reprint, from the Journal of the Italian Spectroscopists, of an elaborate memoir chiefly founded upon the observations of the Rev. George Jones, of the U. S. Navy, but with the use of many observations derived from other sources. The author, rejecting the now commonly received theory of the Zodiacal Light, which attributes its luminosity to sunlight reflected from innumerable small meteoric bodies, comes to the conclusion that it is a purely terrestrial phenomenon, in the nature of an aurora, differing from the polar auroras merely in its having a particular fixed position and by its permanence. He supports this conclusion by a variety of arguments, prominent among which is the supposed occurrence of the auroral line in the zodiacal spectrum, as reported by a number of observers, and he considers the continuous spectrum seen by many other observers as a thing of mere occasional and fortuitous nature. Now, in point of fact, no one making systematic and continuous, observations for a length of time has always found the auroral line present, and the assumption of its presence in the spectrum of the zodiacal light rests chiefly on a few isolated instances, while on the other hand a continuous spectrum is always visible. Again he regards the polarization of the light, determined by careful observations of at least two persons continued for a considerable period of time, as an accidental circumstance, and not as a permanent characteristic. The admission of the reality of this and the continuous spectrum would be fatal to the auroral theory, which even otherwise finds few supporters. Although the author's conclusions may be questioned with good reason, the volume is a valuable contribution to the literature of the zodiacal light, bringing together as it does many excellent observations, and containing interesting particulars respecting the physical aspects of this much discussed phenomenon. A. W. W.

5. *Comets in* 1877.—There have been thus far this year three new comets discovered. a decided contrast to the barrenness in discoveries of the last four years.

(1.) Borrelly at Marseilles found a telescopic comet Feb. 8th, in Ophiuchus. Approximate elements are, $\pi=174° 35'$, $\Omega=187° 20'$, $i=153° 2'$, $\log q=9{\cdot}90712$.

(2.) Borrelly discovered a second comet about the 6th of April.
(3.) Mr. Lewis Swift at Rochester, discovered on the evening of the 11th of April, a very faint comet in the head of Cassiopeia. The discovery was telegraphed the same evening to Professor Henry and to the Associated Press, but for some reason notice seems not to have been sent to Europe. This enabled Borrelly on the 14th to announce his later discovery of the same comet.

6. *Observations of Comets* 1877*b. and* 1877*c. at the Observatory of the Sheffield Sci. School, made by* W. Beebe, H. A. Hazen, and T. A. Smith.—Comet 1877*b.* was observed here at the dates given below. At first it seemed a round nebulous mass, about 5′ in diameter, at first slightly but later more plainly condensed at the center, clearly defined on the side toward the sun, and fading very gradually in the opposite direction, though without any elongation that could be properly called a tail. But on the 21st, after a period of cloudy weather, the comet had become much brighter, with a well-defined nucleus. Two tails were also visible, one extending nearly west along a circle of declination about 20′, and one southwest making with the first an angle of about 60°, the whole forming a kind of fan-shaped tail. The following observations were made with a ring micrometer constructed by Professor Lyman. It differs from the usual form in that it consists of four concentric rings, the largest about a degree, the smallest about 8′, in diameter. By this arrangement any or all of the 8 circles can be used for comparisons, and selections may be made for the best observations, whether for R. A. or dec. Power=60. In absence of a chronograph, or of a clock in the tower, an assistant noted time from a portable chronometer. The names of the first three comparison stars are uncertain.

New Haven m. t.		(C—S), $\Delta\alpha$	(C—S), $\Delta\delta$	Comp. star.	No. Comp.
	h m s	m s	′ ″		
April 7,	16 18 38	+2 17·86	−17 19·15	43397 LL.	11
9,	15 46 31	+6 36·97	−18 52·90	43247 LL.	14
11,	15 26 5	+4 12·09	-- ----	43417 LL.	12
12,	14 41 10	−8 8·89	− 9 4·25	43890 LL.	6
12,	15 26 8	−8 8·92	−12 44·90	43891 LL.	13
15,	-- -- --	6 54·50	-- --	44026 LL.	6

Swift's comet (1877*c.*) was seen here on the evening of the 12th, and the observation then made is perhaps the earliest exact measurement of its place. The comet appeared to be a faint elongated bit of haze less than 1′ broad and was 5′ or 6′ long. With powers of 40 to 200 (object-glass = 8¾ in.) no trace of nucleus was seen or other distinguishing mark. The comet passed centrally over a 10 mag. star, which at first was taken for a nucleus. The place of this star was taken as that of the comet. The comet was again seen on the 22d of April.

New Haven m. t.		(C—S), $\Delta\alpha$.	(C—S). $\Delta\delta$.	Comp. Star.	No. Comp.
	h m s	m s	′ ″		
April 12	9 2 0	−4 43·32	+ 7 51·2	*a*	7
"	9 2 0	−9 16·18	+11 0·2	1951 LL.	5
22	15 19 29	+2 40·00	−15 45·0	*b*	5

App. place, Apr. 22, R. A. $2^h\ 28^m{\cdot}5$. Dec. +60° 18′·5. W. B.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

. *Notes on the Appearance and Migration of the Locust in nitoba and the Northwest Territories, Summer of* 1875; by ORGE M. DAWSON. 18 pp. 8vo. (From the Canadian Natlist.)—Mr. Dawson states that in 1875 the hatching of the ects in Manitoba began in favorable places May 7th, and beie general May 15th. The most northern locality was Mania Lake, in latitude 51°. The movement began in July, and s most general during the latter half of the month and first of gust; and the direction was southeast or south, the insects arently using, by instinct, the winds that favored their pure. Many were carried into a country of thick woods, where y did little harm, and few reached Minnesota. Others passed r Crookston, Polk County, Minnesota, and Fort Totten, Daa; and probably the Sioux City locusts, mentioned by Mr. V. Riley, came from Manitoba.

Other swarms of locusts came from the south across the 49th allel, with a wide front stretching from the 98th to the 108th ridian, which differed from the natives of Manitoba, inasmuch they arrived before the latter were mature. These were "the reme northern part of the army returning, going northward d northwestward, from the States ravaged in the autumn of 4." They appeared at Fort Ellice on the 13th of June, and at 'apelle Fort on the 17th; about Swan Lake House, their most thern point, July 10th. Fort Pelly, farther west, and nearly a gree farther south was reached July 20th. About seven days re occupied in the journey from the latter place to Swan River racks, a distance of only ten miles.

Mr. Dawson concludes that the planting of belts of woodland uld effect in time a general and permanent amelioration of the sshopper plague, since they usually avoid such belts,—their ading the forests in 1875 being perhaps due to the insects ing "lost their reckoning."

The journey southward was regardless of the direction from ich their parents had come the preceding year; and those of braska, Missouri, Kansas and Texas, flew northward and northstward, returning on the course of their parents which had wn southeastward from that quarter; and this movement exded over an immense area from the northern borders of Texas ost to the Saskatchewan River. The normal direction of ht is toward the hatching grounds of their parents, so that two rs seem to be required to complete the migration cycle. The t that the young, while amenable to the migratory tendency, w a determination to exercise it in a direction exactly the osite of the preceding generation is most remarkable.

As to prevention, the methods proposed are the cultivation and servation of forest trees; the protection of the prairie grass il the appropriate time for destroying the young insects in the ching grounds by fire; the protection of insect-eating birds.

Elementary Appendix to all text-books upon iron and steel construction; by Dr. Jacob J. Weyrauch, Prof. Polytech. School at Stuttgart. Translated by A. Jay DuBois, Ph.D., Prof. Civ. and Mech. Engineering, Lehigh University, Penn., with an Appendix by R. H. Thurston, A.M., Prof. Mech. Eng., Stevens Inst. Technol., Hoboken, N. J. 210 pp. 8vo, with four lithographed plates. New York. 1877. (John Wiley & Sons, 15 Astor Place.)—Dr. Weyrauch's work has special importance in this bridge-building country. It treats of the method of dimensioning in iron and steel structures, explains Wöhler's important law, sets forth a new and improved method based on formulæ original with Prof. Launhardt and the author, and presents practical directions and various experimental results, a knowledge of which is essential to safe construction. The translation was made by Professor DuBois, at the request of the author.

8. *The Chemist's Manual: A practical Treatise on Chemistry, Qualitative and Quantitative analysis, Stœchiometry, Blowpipe Analysis, Mineralogy, Assaying, Toxicology, &c., &c.;* by Henry A. Mott, Jr., E.M., Ph.D., &c. 625 pp. 8vo. New York, 1877. (D. Van Nostrand).—This work is a compend of chemical facts and principles. The author has shown skill in the selection of his materials, and has derived them generally from the latest authorities. Many useful tables are introduced, as of Trautwine's specific gravities and weights; formulæ of frequently occurring substances arranged alphabetically; the table of alcohols in atomic series; poisons and antidotes, etc.; Mendelejeff's classification of the elements, reproduced from Watts's second supplement. Under quantitative analysis, are schemes and specific instructions for the analysis of the more frequently occurring commercial products, and in organic chemistry for wine, milk, sugars, both chemical and optical, with much that is not found condensed elsewhere in a form so conveniently accessible. B. S.

9. *Astronomical Myths based on* Flammarion's *History of the Heavens;* by John F. Blake. 432 pp. 12mo, with plates and wood-cuts. London, 1877. (Macmillan & Co.).—The title of this work hardly does it justice; for while containing astronomical myths, it gives in a popular way much of the early history of astronomical ideas, and something of early notions in geography. The chapters on the Pleiades is especially interesting, it bringing out much on the year and festival times of the ancients, and on the astronomical knowledge of the Egyptians and purposes of the pyramids. It has chapters also on the Zodiac; the origin of the Constellations; Eclipses and Comets; Astrology; time and the Calendar; and many other subjects, all of which are treated in a way to instruct and entertain.

The Electric Bath; its medical uses, effects and appliances, by George M. Schweig, M.D. New York: G. P. Putnam's Sons. 1877. pp. 134, 12mo.

Lecture Notes on Elementary Inorganic Chemistry; by E. S. Breidenbaugh, A.M., Prof. Chem. and Min. Pennsylvania College at Gettysburg. 72 pp. 8vo. Gettysburg, 1871.

Interpolation and adjustment of Series; by E. L. DeForest. 52 pp. 8vo. New Haven, 1876.

THE

AMERICAN

URNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

T. XLIII.—*An account of the Discoveries in Vermont Geology of the* Rev. AUGUSTUS WING; by JAMES D. DANA.

[Continued from page 347.]

N the preceding part of this paper the discoveries have been iounced of *Trenton fossils* in crystalline limestone in North itleton, Hubbardton, and Sudbury, within the area of the reat central slate-belt;" in East Cornwall just east of the belt; t of the village of Shoreham; in Eastern Orwell; in Middle- y, and north of East Cornwall—indicating a north-and-south a of Trenton limestone either side and underneath the slate, l showing the slate to be probably the Hudson River shales; *Chazy fossils* at West Rutland; in East Cornwall; northeast of village of Orwell; in West Cornwall; in North Cornwall at sworth Ledge; at Weybridge Upper Falls northwest of Middbury; of *Quebec fossils*, south of the East Cornwall locality Trenton fossils, and in North Cornwall at Ellsworth Ledge; *Calciferous fossils* near the borders of West Cornwall at scom's Ledge; in Northeastern Shoreham at Mutton Hill, l also in another fold near by (affording a small species of *thoceras*, etc.); near the border of West Cornwall at Bascom's lge, and at Barbour's Ledge in South Bridport.

he Eolian limestone extends north through Middlebury l New Haven and terminates in Monkton, and affords other sils in its northern portion.

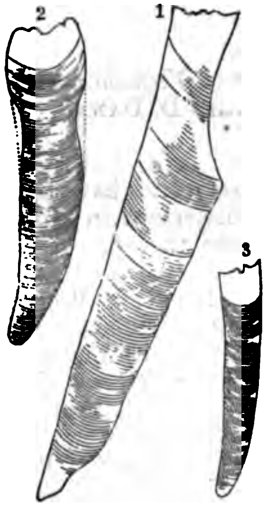
6. *Northern Middlebury, New Haven, Monkton.*

About two miles north of Middlebury, a few rods east of the d running by Messrs. Hammond's to the Severance (or Old

Middlebury) Marble Quarry, half a mile west-by-south from the quarry, across a small stream, there is a thin bed of limestone dipping to the east 70° or 75°, underlaid on the west by six or eight feet of dark fine-grained quartzyte holding *Scolithi.* At this place ten or twelve specimens of a small *Orthoceras* occur, weathered out over the exposed surface of limestone near the place of contact with the quartzyte. The Orthocerata are tapering in form, three to five lines in diameter and one to two inches long, and have very fine close septa. The species is very much like the Calciferous *Orthoceras* figured by Hall in the New York Report.

I visited this locality, on my excursion with Mr. Wing, and found his description right; the specimens are beautifully distinct although only worn sections. Expecting that Mr. Wing would describe the Orthoceras, and also hoping that I should receive from him a specimen (which only long working with a quarryman's tools could safely dig out), I took no satisfactory notes at the time. Through the kindness of Professor H. M. Seely, I have had "squeezes" from three of the specimens, showing well the character of the septa, and have further learned that the number of septa is from ten to thirteen in a quarter inch, that is forty to fifty-two in an inch; and I have also received drawings made on the spot by Miss Parker. The accompanying three figures are from these drawings and the squeezes. They are natural size; and Professor Seely observes that there are indications, though doubtful, that the upper end of No. 1 may have been half an inch longer. The figures are restorations only in having part of the septa more entire than in the specimens.

14–16.



They show that the species is much like *Orthoceras primigenium* Hall, but that part have a slight curve. Mr. Wing's earliest notes on this locality among those in my hands, occur in a letter dated October, 1867.*

Half a mile northwest of the Orthoceras locality and two and a half miles northeast of Middlebury village, and apparently in the same formation with the last, there are specimens resembling *Ophileta compacta;* there was also found here a large *Maclurea.* "The figure here given is correct as to size and general form, though not having the grace of the original."

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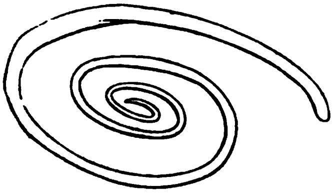
* I repeat here that the paragraphs in smaller type consist of remarks by the compiler of this paper, and of facts from other sources.

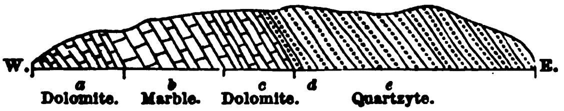
17.



About a mile southwest of the Middlebury quarry and thirty or forty rods west of Mr. E. Kirby's residence, in an old orchard, several distinct convoluted shells were seen on a dark siliceous limestone dipping west. The beds are probably Calciferous.

The quartzyte near the old Middlebury Marble Quarry above-mentioned extends northward into the town of New Haven to New Haven River, a distance of about two miles. The following figure represents a section taken south of New Haven River on the southern border of the town of New Haven. There are in succession, going eastward along the lines of section, 150 feet of dolomite (*a*); 200 feet of marble (*b*); 150 feet of dolomite (*c*); 10 feet of gray quartzyte (*d*); 800 feet (*e*) of buff and reddish quartzyte with some slate. The quartzite has been made the overlying rock in the view of Mr. Wing by an overthrow fold. This quartzyte belt, with the limestone west of it, stops at New Haven River. But, 80 to 100 rods to the west, another belt begins which stretches northward, passing just east of New Haven village (four miles from New Haven River), and finally joins the Red Sandrock of Monkton.

18.



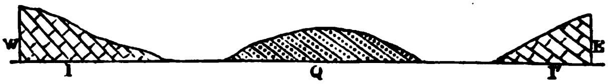
Section south of New Haven River on the southern border of New Haven town.

At a place two and a half miles south of New Haven village, in a field belonging to Mr. J. Brown, a small *Orthoceras* was found over the weathered surface of the dolomite just west of the quartzyte, which was apparently identical in species with those of the locality above-mentioned. The *Orthoceras* is closely like that of Shoreham (figured on page 342), which was found in limestone adjoining the underlying sandrock. The quartzyte at Mr. J. Brown's, two and a half miles north of New Haven village, is 400 to 500 feet thick, dips eastward at an angle of 50° to 60°, and contains "numerous Fucoids and obscure Scolithi."

This locality is one of those I visited with Mr. Wing. The quartzyte is situated between limestone on the east and west, all dipping alike. The dolomitic limestone to the east has a reddish

color seamed with white, somewhat brecciated, and resembles much the red Winooski limestone (Primordial). The quartzyte ridge was nearly half made up of hydromica slate.

19.



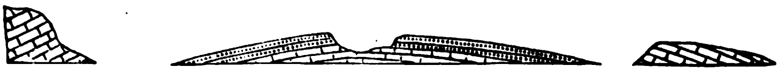
Section near Mr. J. Brown's.

For a mile northeast of the Weybridge Upper Falls, across the railroad, the "striped stratum" is seen in short anticlinals without fossils; but in a fold skirting the western foot of Town Hill, near an old lime-kiln, on the farm of A. Lorraine, three miles southwest of New Haven village, *Rhynchonellæ* were found. The same formation extends on and contains fossils in Brookville, and "in northeastern Middlebury east of Chipman Hill, a little north of Mr. Foot's residence, just east of the road going to Mr. Hammond's."

In the northwestern part of the town of New Haven, one and one-half miles north of New Haven depot, a few rods west of Mr. Charles Mason's residence, the road to Monkton cuts through the western border of a low quartzyte anticlinal, having an eastward and westward dip in the opposite directions. Following the quartzyte northward twenty-five or thirty rods, *Fucoids* and *Scolithi* are found in it. The quartzyte to the west and east dips under heavy beds of "dolomitic siliceous limestone." Farther east there is a thick stratum of white crystalline limestone or marble; next, beds of "sandstone" and concretionary limestone; next, a coarse "sandstone" conglomerate; next, limestone. "Obscure *Orthocerata*, convoluted shells and an *Orthis* were seen," and they appear to be fossils of the "Ophileta beds" or Upper Calciferous. "The limestones end in Monkton not half a mile north of this place," the rock beyond being the Red Sandrock, with its *Scolithi* and *Fucoids*. The Calciferous formation is thus traced to the northern limit of the Eolian limestone.

At my visit to the quartzyte anticlinal just described, I found that there was a small cross-gorge in the quartzyte, showing that the quartzyte had little thickness and that it overlaid a stratum

20.

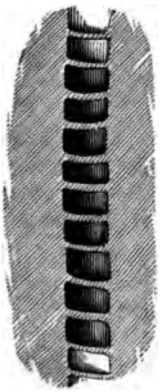


Section of Quartzyte Anticlinal.

of limestone, probably dolomitic, twenty feet in height of which were exposed to view. The beds at this place have only a small dip. The general relations of the beds are shown in the above section.

The quartzyte is in most parts a little slaty in structure, and in limited portions a shining grayish-black slate. In places over it there are areas of sub-concentric conchoidal lamination, looking somewhat as if examples of the flow-and-plunge structure, but more probably a result of concretionary consolidation. To the latter cause I attributed some forms that looked exceedingly like casts of a *Pleurotomaria* and a *Murchisonia*, and of a valve of *Orthis lynx*. Others of these imitative forms over the surface were semi-cylindrical and chambered, as if worn casts of long crinoidal stems; yet having the chambers too large and irregular for any known crinoidal forms. A portion of one of them is here figured natural size; its total length was over ten inches. These simulations of Crinoids may also be due to a concentric structure in the slaty portion of the rock; yet how, it is not easy to understand.

21.



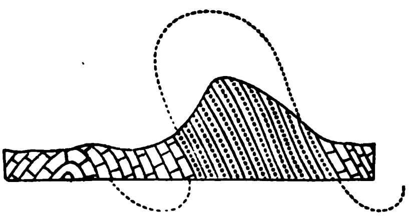
7. *Eastern portion of the Eolian Limestone belt, and the Quartzyte adjoining.*

In this eastern portion of the Eolian limestone, constituting one-fourth to one-third of the whole breadth, no fossils have been found. The more crystalline character of the rock accounts for the absence of fossils. Conclusions as to its age and that of the quartzyte have to be based on other considerations. This evidence of intenser metamorphism on going eastward is apparent beyond the limits of the limestone region, to and beyond the Green Mountain axis.

The interstratification of the quartzyte and Eolian limestone is illustrated in the section given on page 340, in which two bands of dolomite are included between belts of the quartzyte.

In July, 1875, Mr. Wing made, along with Professor Seely, a special examination of the quartzyte mountain called the "Hogback," forming the northern terminus of the Vermont Quartzyte range, and lying near the western foot of the Green Mountains. At the north end of the Hogback a low hill, situated north of the road to Starksboro, is of hard grayish quartzyte, while the main range south is brownish and distinctly stratified, with the dip 70° to 75° to the eastward. North of this low quartzyte hill, the quartzyte extends on northward in narrow masses, and is directly overlaid on the northeast by dolomite and bounded by the same dolomite around the whole northern end. The dolomite on the west was not seen in immediate contact with the quartzyte; but at the nearest point, "some rods distant," it seemed to dip east at a high angle, while a few rods to the west it had a decided westward dip. On the *east* side of the quartzyte at this northern end of the range, and also south to Starksboro, there is another north-and-south range of limestone (dolomite), having an eastward dip conformable to the quartzyte (as represented also in the Vermont Report, p. 346). The figure here given (copied from Mr. Wing's note book) gives his view of the stratification.

22.



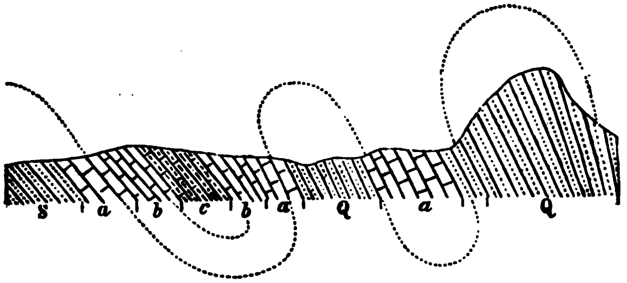
Mr. Wing's section through Hogback.

At Starksboro, *east* of the dolomite, there is a quartzyte ridge which "for a height of 3,000 feet seemed to be an immense flag-stone quarry; the rock is quarried for flagging farther north. It may be called brown quartzyte; it is within the 'Talcose Conglomerate' area of the Vermont Geological Report." The layers are nearly vertical, having a very high eastward dip, conformable with the dolomite and with the quartzyte lying west of the dolomite. The whole valley between the two ranges of quartzyte,—a nearly level strip of country "embracing two or three villages, excellent farms and farm-houses,"—seems to have been made by erosion, the dolomitic and slaty strata having been worn away faster than the quartzyte of Hogback on the west and the Flag-stone ridge on the east. The only fossils of the quartzyte are the *Scolithi* and *Fucoids* observed elsewhere, and these are the same with those of the Red Sand-rock.

The conclusion given in the notes of this excursion in 1875 is,—that "all the rocks in Bristol north and east of Mr. Oaks's residence (on the road next west of Bristol village), all in Monkton and in Starksboro, are older than the Calciferous; the dolomites belong to the Red Sandrock series, or that of the quartzyte, and in some places appear to be 400 to 500 feet thick; and they overlie the quartzyte, being beneath because of an overturn anticlinal." These dolomites here referred to the Red Sandrock series are those called "Subcrystalline limestone" on page 343, which contain the Calciferous *Orthoceras* at Mutton Hill and are there referred to the Lower Calciferous. The following section (from the letter of 1872,) represents the rocks between the Red Sand-rock west of New Haven (see map) and the quartzyte at the village of Bristol, and Mr. Wing's view as to the folds. *a*, The Red Sand-rock dolomite or "Subcrystalline limestone;" *b*, The "Ophileta beds" or Calciferous; *c*, The "Conglomerate" or "Trilobite bed" or "siliceous limestone greatly resembling it," underlying to the south on the strike, "Rhynchonella beds" containing fossils;

Q, quartzyte. Adjoining the Red Sandrock on the west is No. 2 of the section on page 343, a "dolomitic sandstone."

23.

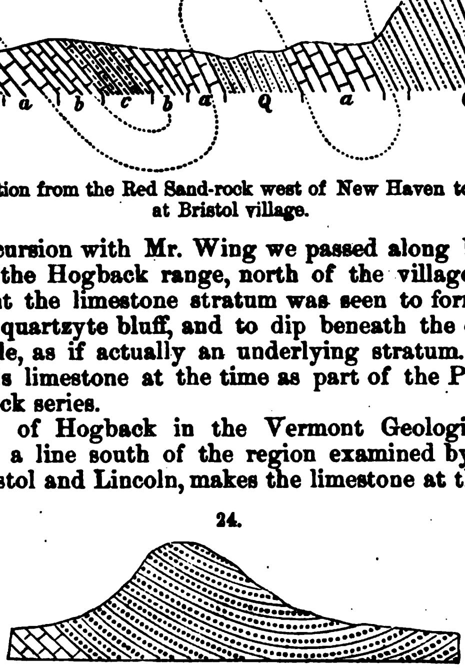


Mr. Wing's section from the Red Sand-rock west of New Haven to the Quartzyte at Bristol village.

In the excursion with Mr. Wing we passed along by the western foot of the Hogback range, north of the village of Bristol. At one point the limestone stratum was seen to form the lower part of the quartzyte bluff, and to dip beneath the quartzyte at a small angle, as if actually an underlying stratum. Mr. Wing spoke of this limestone at the time as part of the Primordial or Red Sand-rock series.

A section of Hogback in the Vermont Geological Report, taken along a line south of the region examined by Mr. Wing, between Bristol and Lincoln, makes the limestone at the *west* base

24.



Section of Hogback, from Vermont Report.

of Hogback dip eastward 45° or so beneath the quartzyte. To the eastward of Hogback along this section no limestone is represented in the figure; but the Report says (p. 346): "in the valley of the north branch of New Haven River, passing up to Starksboro, there are ledges of limestone occasionally seen, interstratified with the quartz rock, nearly as far as Starksboro village; and there is reason to believe that it may extend to meet a narrow belt of limestone running south from Hinesburgh."

In my examination of the limestone and quartzyte ridge northeast of Rutland, I found that the dip in both was eastward; but the nearest outcrops of the two were too remote to make it sure that they were conformable. They are conformable according to the section through Rutland and Mendon given in the Vermont Geological Report. The quartzyte in Vermont is in many places interstratified with, and replaced by, hydromica slate (sometimes chloritic), or a hydromicaceous quartzyte or conglomerate—a fact dwelt upon in the Vermont Geological Report, which says as follows, when describing sections across the eastern quartzyte range. In Sunderland the quartz-formation includes, with quartzyte, talcose schist [that is, hydromica slate] (p. 614). In Wallingford the quartzyte and quartz conglomerate are interstratified with talcose schist (p. 627). "Talcose schist is associated with the quartz-rock of Mendon" (p. 634). In Goshen "the quartz rock formation is composed of hyaline quartz, talcose schist, and argillo-talcose schist" (p. 640). In Ripton "the quartz-rock is composed of ten bands of different rocks, viz: hyaline quartz, compact sandstone, talcose and chlorite schist" (p. 645). Speaking of the belt of "talcose conglomerate" it says that it includes sandstones, breccias, quartzyte, coarse conglomerates, talcose schist, novaculite schist, and "talcose schist is the most common rock in the belt" (pp. 386, 387).

I have examined this association of hydromica slate and quartzyte in the quartzyte ridge northeast of Rutland (the ridge making the western boundary of the town of Mendon). Having on my second visit struck the ridge at a different point from that examined on my first visit, I was perplexed by finding hydromica slate in place of true quartzyte; but afterward reached an explanation on observing the gradations of one rock into the other. The Geological Chart of the Vermont Report does not generally represent this interstratification of the quartz and hydromica slate, as the Report observes, because the details were not separately made out owing to the intimate relations of the two. It is shown, however, in Section VIII, where, near Ripton, occurs the remark "Quartz rock interstratified with talcose schist;" and bands of color in the colored section represent the fact.

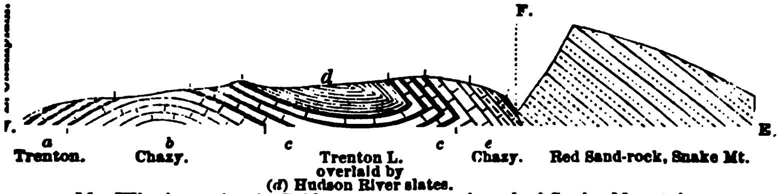
8. "*Great Fault of Western Vermont.*"

Snake Mountain is a north-and-south ridge of Red Sand-rock several miles long, situated to the west of Middlebury, within seven miles of Lake Champlain. It has a steep western face, and gradual eastern slopes—the former across the stratification, and the latter nearly conforming with it. This western side is the course of a great fault.

The rock of Snake Mountain east of the fault is the Red Sand-rock of the Vermont Report, and this continues to be the surface rock eastward to Otter Creek. [illegible] extremity of the mountain, in [illegible] there are the successive Lower [illegible] inverted position. The [illegible] position of the beds observed [illegible]

The first and uppermost [illegible] fossils is the Chazy; below [illegible] Hudson River, so that the [illegible] back for two or three miles upon the slate. This arrangement in the main prevails along the west front of Snake and Buck Mountains to near Vergennes.

25.



Mr. Wing's section in Bridport, across south end of Snake Mountain.

"Along the highest part of Snake Mountain no slate or limestone is seen at all. At the north end of the mountain the Red Sand-rock has been lifted until it is 700 feet above the level of the Hudson River slates to the west, while at the south end, four or five miles distant, it is much less elevated. Around its northwest end, only the Hudson River slate is seen. Then the Chazy comes in behind the Trenton, and both are folded over on the slate. The Chazy, Trenton, and the Hudson River slate disappear in the same order farther south. The Red Sand-rock (Potsdam) appears to have been pushed up and thrust west over these other formations; and so far over, opposite the highest part of the mountain, as to conceal first the Chazy, the Trenton and the Hudson River beds; then, farther north, leaving the Hudson River beds, Trenton and Chazy, along the lower part of the mountain."

The Chazy beds on the west of the fault afford large *Maclurea*: one or two species of *Orthoceras*, an *Orthis*; the Black River limestone, *Columnaria alveolata* in great masses, besides [illegible] species; the Trenton, *Trinucleus concentricus*, and [illegible] other fossils, and the Hudson River slate its characteristic species.

This fault continues south through Bridport, [illegible] ham and Orwell to Orwell villag[illegible] beyond, "but [illegible] irregularity of direction, it follo[illegible]her a meri[illegible] line of a belt or fold."

"Two or three miles [illegible] west of [illegible] Shoreham [illegible] Barnum's [illegible]

Prof. Emmons describes the fault at Snake Mountain and gives a section in his American Geology (vol. I, Part 2, p. 87, 1855); but his section seems to have been taken north of the point described by Mr. Wing; the place is not stated. It makes the formations to the west of the fault lie in regular instead of inverted order. Professor Emmons supposed the rock of Snake Mountain, raised by the faulting, to belong to his Taconic System and therefore pre-Silurian. Prof. Hitchcock, in the Vermont Geological Report, gives a section which represents the mountain *without the fault.*

9. *Conclusions of Mr. Wing as to the Geology of the part of Central and Southern Vermont investigated by him.*

1. The hydromica slates, clay slates, Eolian limestone and quartzyte, with the so-called talcose conglomerate on the east, are all of Lower Silurian age, and conformable in superposition.

2. The Eolian limestone is not Taconic, as made by Prof. Emmons; nor of some one formation, as implied in statements in the Vermont Report and in the name it gave it; nor of the Quebec group, as inferred by Logan; it includes Lower Silurian limestones of various periods, the Upper Potsdam or Lower Calciferous, Calciferous, Quebec, Chazy, Black River, and Trenton.

3. The Red Sand-rock on the west of the Eolian limestone—admitted to be Potsdam or Primordial in age—and the Quartzyte on the east which often rises into mountain ridges, are of the same formation, and come nearly or quite together in Monkton, on the northern limits of the limestone area.

4. These rocks—the Red Sand-rock and Quartzyte—are the western and eastern borders of a great abraded synclinal, the axis of which in its northern part has a slight northward rise (or southward dip), the sides there coming together; and which also has both the eastern and western sides of the fold eastwardly inclined, the dip of the beds being generally eastward. Between its borders there are, in some parts, subordinate longitudinal abraded anticlinals and synclinals.

5. The slates of the "great central belt" are of the age of the Hudson River slates (or that of the Cincinnati group), for the reasons stated on page 345—which are briefly these: (1) the slate-belt is bordered in several places on both the east and west sides by limestone affording Trenton fossils (*Trinucleus*, etc.), and no where else have Trenton fossils been found in the Eolian limestone; (2) there are also narrow north-and-south outcrops of limestones containing Trenton fossils over the interior of the slate-belt, as if brought up from beneath by anticlinals; (3) the slate-belt is plainly underlaid by the limestone at its north end; (4) in Whiting the Trenton limestone of the Sudbury area has a direct connection, across the slate area, with the limestone of Otter Creek valley, east of the belt, which also is Trenton in age —the slate being interrupted "for forty or fifty rods."

The Trenton limestone has been identified west of or within
e "central slate-belt," at localities but a few miles apart, in
. the towns north of Castleton (the most southern on the map
ustrating this paper, p. 335), including, in succession, Hub-
rdton, Sudbury, Whiting, Shoreham, Cornwall, Weybridge;
d east of the slate-belt, in Leicester, Eastern Cornwall and
iddlebury. The Chazy limestone adjoins the "central slate-
lt" in West Rutland.

6. The several Lower Silurian limestone formations lie in
rth-and-south belts, with the lowest—the Potsdam and Cal-
erous—nearest to the Red Sand-rock, or to the Quartzyte,
d the upper—the Trenton or Chazy—nearest to the "central
ite-belt." This view is presented in the section from East
oreham to East Liecester on p. 340.

This is confirmed as regards the Trenton limestone, "Sparry
nestone," by the list of its localities just mentioned. The
iazy ("Rhynchonella beds") so well represented by fossils at
est Rutland, has afforded fossils also in Leicester, East Corn-
ll, Middlebury, and the same fossils have been found on the
st, as on the west, of the "central slate-belt;" while the
triped stratum," which is a marked feature of the Chazy,—
, way-mark by which the rock can be recognized without its
ssils," occurs also in Middlebury, in the western part of Bran-
n by the Burgess Field farm and along the quarries of this
rt of the town, in the western part of Pittsford, and in North-
i Salisbury; and "doubtless it reaches the marble quarries of
est Rutland, and continues south through Tinmouth and the
iole State; and in this formation is embraced the Birdseye and
ack River limestones." "On Crown Point, Lake Champlain,
ese 'striped beds' are largely developed at the old Forts, and
perhaps 100 yards beneath the Black River limestone—
iether in the Chazy or Birdseye is not known. There is a
atum of seemingly pure sandstone, resembling the Potsdam,
erlying them at Crown Point. These facts may help to solve
e age of the same 'striped beds' in Addison County."

The groups affording the lowest Calciferous fossils on the west
the "central slate-belt" occur next to sandstones of the Red
ndstone formation; and also at two localities north of Mid-
ebury, adjoining beds of quartzyte, or where the limestone
d quartzyte come together. The "Ophileta beds," or those
erred to the Upper Calciferous, come next, being more remote
m the sandstone or quartzyte, as found to be true in Shoreham,
estern Cornwall, Weybridge, Middlebury and New Haven.
The beds occur, with their fossils, in Salisbury, Leicester and
andon.

The eastern range of limestone, or that forming the eastern
rgin of the great Eolian belt, a mile in width in many places

but narrower to the north, is concluded to be Calciferous or Upper Potsdam, because it adjoins the quartzyte, and is dolomitic, the limestone nearest to the outcrops of quartzyte in Northern Middlebury and New Haven being proved by its *Orthocerata* to be—like that nearest the Red Sand-rock to the west of Shoreham—of Calciferous age, if not Upper Potsdam.

The localities affording the Calciferous fossils (Ophileta beds) in Salisbury, Leicester and Brandon lie a little to the west of the great marble formation; and this marble formation is considered the equivalent of the western "Subcrystalline limestone" just above the fucoidal sandstones or Upper Potsdam. The dolomites farther east belong to the Upper Red Sand-rock series, or else the bottom of the Calciferous, as has been elsewhere stated.

The later formations extend less far north than the older because of the inclined axis of the great abraded synclinal: "the Hudson River slates (those of the "central slate-belt") reaching central Weybridge; the Trenton, about a mile farther; the Rhynchonella beds five or six miles farther north; and finally these disappear, owing to the rising into view of the Red Sand-rock."

7. The quartzyte of the eastern range, with that also of the local belts in the Eolian limestone area, is regarded as Potsdam (or Primordial) in age, because it contains in many places *Scolithi* (worm-burrows) and *Fucoids* like those found in the Potsdam sandstone; because also it adjoins Calciferous limestone beds at the localities just mentioned in North Middlebury and New Haven; and because it joins the Red Sand-rock in Monkton, and one rock has in many places the character of the other, although not commonly alike in color, and showing differences explainable on the ground of the greater metamorphism of the quartzyte. "In Monkton, the Red Sand-rock and the Quartzyte meet in a succession of short anticlinals, thus cutting off to the north the great trough or synclinal;" and "the Red Sand-rock absolutely overlies the beds of Red Sand-rock in one anticlinal and the quartzyte in another anticlinal, and both hold *Scolithus linearis.*

8. The quartzyte belt of Rutland Center (just north of Rutland), with the associated slate, extends north by Sutherland Falls nearly to Forestdale, and it runs south of Rutland Center into Clarendon and Tinmouth. It lies throughout within the Eolian limestone area. But it is seen on the map that the area is on the line of strike of the quartzyte-range north of Pittsford. This quartzyte is regarded as Potsdam; and the limestone which lies directly to the west of it (half way from Rutland to the West Rutland valley) is supposed to be possibly the "Ophileta beds" or Upper Calciferous, and the "Conglomerate" or Quebec

roup. "But this narrow valley is a very disturbed region, nd the limestone seems to be greatly compressed between the uartzyte belt on the east and the slate belt on the west (separating it from West Rutland valley)." "The region was stud-d farther south in the valley as well as to the north, to ascer-tin what rocks occurred, and the conclusion was that nearly ll the formations found in other places here occur; that is, the lder on the east against the quartzyte (No. 1), and then the thers in succession, with the Trenton against the slate bound-ıg the limestone on the west, while the slate is No. 8 or the Iudson River slate." No fossils were found in it.

10. *Historical Note.*

The preceding notes have been taken chiefly from the letter from Ir. Wing to me dated August 9, 1872. They show that his view, hat there are Hudson River slates in the Eolian limestone region, ntedates my own; for my paper on the subject was not published ntil 1873, and there had been no communication between us before hen on the subject, or on any subject. Moreover, my own views s to the age of the Berkshire rocks were based chiefly, as I stated, n Mr. Wing's discoveries in Vermont. I cite the following from letter to me, of May 8, 1875, written soon after he had first seen ıy paper on the subject—a letter never, however, received by me ntil his papers were recently put into my hands. It shows that is conclusions date as far back as 1866.

"When, in 1866, the *Trinucleus concentricus* and other Tren-on fossils were found first in Sudbury, underlying on the west ide the great central mass of slate running south from Wey-ridge through the State, embracing the "Talcoid schists" cap-ing Dorset and Manchester Mountains, Mount Anthony in Iennington, and also Graylock in Massachusetts, I reached the onclusion at once that all these slates in Southwestern Vermont nd Southwestern New England were neither of the Quebec roup, nor Taconic, but of the age of the Hudson River slate. n the progress of my investigations, I assumed, and I often xpressed in correspondence with Mr. Billings, that the 'Eolian imestone' of the Vermont Geological Report embraced not nly the Trenton and Hudson River beds, but all the formations f the Lower Silurian as well, and even limestones and dolomites f the Red Sand-rock series. I was wrong at first in assuming hat these same slates overlying the Trenton and Chazy limetones along this central belt extended also west to the Hudson Iiver and were all of the same age. For the Primordial fossils ecently collected at Bald Mountain, Washington Co., and east f Troy, New York (both of which places I have visited), have nodified my view as to the western extent of the Hudson River lates. But they have not weakened my belief in their existence n Southwestern Vermont and New England."

From the preceding account of Mr. Wing's discoveries it is evident that he performed well the task he laid down for himself in 1865—the determination of the age of the Eolian limestone. Knowing that fossils were the only sure criterion of geological age, he searched, and he found them, and thus reached sure conclusions. For the western portion of the Eolian limestone and more than half the eastern (that of Otter Creek Valley), the special geological age was thus determined, and the several Lower Silurian formations identified. He further made a right use of the facts, when, in view of the Trenton and Chazy age of the fossils in limestone along the borders of and within the "central slate-belt," and the observation that the beds more remote are successively older—he deduced that the slates were younger than the limestones holding the Trenton fossils, and therefore, in all probability, of the Hudson River (or Cincinnati) group, and that they lay in a synclinal with Trenton and older limestones beneath and on either side.

The more highly metamorphic condition of the limestones making the eastern border of the Eolian limestone prevented his giving to the geology of this part of the region the same positive basis from fossils which he had obtained for the rest.

The Quartzyte also proved almost barren, yielding him only *Scolithi* and *Fucoids*, neither of which serve to fix positively the age of the beds. His argument with respect to it from the well-defined Calciferous fossils found adjoining quartzyte at three different localities on the west and north is however a strong one, and seems to set the question at rest for those outcrops. The Vermont Geological Report states that the eastern Quartzyte range, near Rockville in Starksboro, has afforded a *Lingula*—the specimen containing "scores of fossils but none very distinct"—which Prof. James Hall "regards as a new species related to one in the Medina sandstone," and as evidence "though unsatisfactory" that the quartzyte is of the age of the Medina. From the same Quartzyte range farther south, in the vicinity of Lake Dunmore, Prof. C. B. Adams, as it states, found a shell near a *Modiolopsis* in form; also a tapering shell looking like an *Orthoceras*. Yet the determinations of all these fossils are admitted to be doubtful, and the question of age is still an open one.

One of the most important points established by Mr. Wing is the conformability of the Lower Silurian formations throughout the region. From the Red Sand-rock, or Primordial, upward they make one consecutive series, and all are involved, as Mr. Wing urges, in one system of synclinals and anticlinals. The quartzyte, hydromica slates, and limestones, associated on the eastern border of the region, and the great bands of limestone, hydromica slate and clay slate (or roofing slate), with some quartzyte, making the center and western portion, are of one system, and took, together, their present positions. The great fault which made Snake Mountain was simply one of the breaks and displacements attending the mountain-making movement, as shown years since by

ı. The observations of Mr. Wing afford nothing to sustain
ew that there was an epoch of disturbance in the region at
ose of the Primordial or Cambrian period, but, on the con-
they prove that the rocks went on forming in regular suc-
n nearly or quite to the close of the Lower Silurian; and
hen followed, as Mr. Wing concludes, the epoch of upturn-
ıd metamorphism. The making of the Green Mountains has
ıny years been referred by some geologists to this epoch, on
ısis of the fossils in the limestones of Vermont. These
developments leave no doubt that this view is right, at least
as the Eolian limestone of Vermont and the associated
s and quartzyte are concerned.

another number of this Journal I will close this subject by
g the bearing of the Vermont facts on the geology of Berk-

XLIV.—*On Barite crystals from the Last Chance Mine, rgan County, Missouri; and on Göthite from Adair County, souri;* by G. C. Broadhead.

1. *Barite from Morgan County, Missouri.*

E rocks of the barite locality in Morgan County, Missouri,
the age of the Second Magnesian Limestone. A shaft has
sunk in a spring through masses of tumbled rock display-
hat seemed, in Missouri miners' parlance, to be a "circle"
out twenty feet diameter. This "circle" was found to
led with fractured masses of limestone, sandstone and
or forty feet in depth, or to the bottom of the shaft when
ted it. These masses of rock were often found studded
with beautiful crystals of barite. The galenite was also
covered with such crystals. In some cases a thin coating
nsparent barite covered the rock to which the crystals
ed, but they were often seen loosely adhering to the
l rock.

form of these crystals is different from any heretofore
in Missouri. They are elongated into prismatic forms
n the direction of the macrodiagonal axis and are attached
rock by one of its extremities. The development of the
plane gives them a flattened appearance. The free ex-
ty of the crystals is gradually sharpened off to a thin
through the presence of very low macrodome. This is so
ılarly developed, however, as not to admit of trustworthy
ırements, but seems to have the symbol $\frac{1}{8}\text{-}\bar{\imath}$. The central
n of all the crystals toward the attached extremity is
tly transparent. This clear portion has a rhombic form
ponding to the fundamental (cleavage) prism, and is

very sharply defined, the remainder of the crystals being of an opaque milky white.

There being a spring of water in the mine. the water may be sometimes charged with an excess of mineral solutions. The lead has probably been deposited from an aqueous solution and the barite from similar and more recent solutions. The waters also seem to have subsequently held iron oxide in solution as some of the crystals of barite are coated with it.

A crystal in my possession from the Cordray mines, but probably from same mine as the above, possesses similar characteristics. It is of rhombic form, about two inches long and a half inch thick; the edges are bevelled by the plains $\frac{1}{2}$-$\bar{i}$ which gave on measurement the angle 77° 40′. It has a border a half inch wide of white opaque barite, the outer angle sharp, inner angle truncated, and the remainder is clear mineral, which corresponds in shape to the cleavage prism; the direction of the cleavage is also indicated by cracks across the crystal. The white portion of this crystal would seem to indicate alteration, but that can hardly be the cause of the similar appearance of the crystals from the Last Chance mine.

2. *On the Göthite from Adair County, Missouri.*

The Coal measures, it is well known, often contain, within the thicker shale beds, interstratified beds of clay ironstone, sometimes in connected layers, at other times in concretionary masses, occurring along a marked horizon. These concretions are often reticulated by calcite veins, one system in concentric lines, the other crossing them; they are generally termed septaria.

In 1873, while examining the structure of the formations on Chariton River, Adair County, Missouri, I broke open a number of the concretionary masses which were reticulated by veins of calcite from a quarter to half an inch wide, occasionally widening into small cavities one-eighth to one-half an inch high, lined with calcite crystals reposing on the more compact calcite of the vein. Upon and sometimes interpenetrating these crystals are small slender acicular crystals of black göthite, generally not more than an eighth of an inch, but sometimes as much as three-fourths of an inch, in length. The göthite is generally aggregated in bundles at the base of the calcite from which they radiate. Sometimes a single crystal will shoot directly through a calcite crystal. Sometimes also, a single point of a quartz crystal will be seen penetrated in various directions by the göthite. The calcite, often, has its angles bevelled or rounded, and they were sometimes colored red on the surface as was also a little of the göthite. Minute velvety balls of göthite not larger than the one-thirty-second of an inch were also found reposing on the calcite.

Pleasant Hill, Mo., March, 1877.

RT. XLV.—*Estimation of Chromium and Aluminium in Steel and Iron;* by ANDREW A. BLAIR.

HAVING had occasion, several years since, to examine a numer of samples of so-called "Chrome-steel," for the percentage f chromium, I began by searching for this element in the resiue left after acting on the steel with dilute HCl, as, in the case f cast-iron, this plan is recommended.* Failing to find it here, cept in very small amounts, there seemed to remain two ethods of procedure: the first being to fuse the sample with a_2CO_3 and KNO_3, either directly† or after oxidizing‡ by NO_3 and evaporating to dryness; the second, to treat the lution of the steel containing the iron as a ferric salt, with HO, Na_2CO_3 or Na_2CO_3, and $NaC_2H_3O_2$, in excess, and in is alkaline or acetic acid solution oxidizing the Cr_2O_3 to rO_3, by means of Br, Cl, PbO_2 or $KMnO_4$, which combines with e alkali as a soluble alkaline chromate, while in the cold or pon boiling, the iron is precipitated as hydrated sesquioxide r basic acetate.§ While both of these general methods will ndoubtedly give good results, when large amounts of chromium re present, so that small amounts of the original substance can e operated upon, they present many objectionable features when e percentage of chromium is small, and the amount of steel r iron that must necessarily be used is correspondingly large. he principal objections are, in the first method, loss by spirtg during fusion, and in both, the difficulty of washing the oluminous precipitate of iron free from alkaline chromate. third general method, viz: separating the Cr_2O_3 from the e_2O_3 by means of $C_4H_6O_6$, NH_4HO, and NH_4HS, exactly s in the separation of Al_2O_3 and Fe_2O_3, might be added, but e difficulty of washing such a mass of ferrous sulphide seemed uite impracticable, and the method was not even attempted.

By means of barium carbonate, Cr_2O_3 may be perfectly preipitated,‖ and thus separated from the great mass of the iron, hich in a hydrochloric acid solution of the steel would exist s a ferrous salt. Following out this plan the result was the llowing method.

Five grams of borings or drillings are weighed out into a flask.

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* Wöhler's Mineral Analysis (Nason), p. 204.

† Watts's Dict. of Chemistry, vol. iii, p. 374.

‡ Rose's Chim. Anal. Quant., (French ed., 1862), p. 987.

§ Crookes's Select Methods, p. 127. W. Gibbs in Am. Journ. Science (II), xxxix, 3. Chancel, Compt. Rendus, xliii, 927.

‖ Rose, Chim. Anal. Quant., p. 513. Fresenius, Quant. Chem. Anal., vi ed., Engh, p. 379.

of about one-half liter capacity, twenty cubic centimeters strong HCl diluted with three to four times its volume of water poured in, and the flask closed with a rubber stopper, provided with a valve, such as is used in dissolving iron wire in volumetric analysis. Heat is applied as required, and, when all the steel is dissolved, a solid stopper is quickly substituted for the one with the valve, and the flask and contents cooled. When cold, the solution is diluted with cold water until the flask is about three-fourths full, and a slight excess of $BaCO_3$ added with constant agitation. The $BaCO_3$ should be free from $BaSO_4$, as it obscures the reaction, and too great an excess should be avoided.* The flask should be thoroughly shaken several times, loosening the stopper occasionally to allow the CO_2 to escape, and allowed to stand over night. It is then filtered as rapidly as possible, the flask rinsed out several times with cold water, and the precipitate on the filter (consisting of all the Cr_2O_3, the residue from the steel insoluble in dilute HCl, some Fe_2O_3 and the excess of $BaCO_3$) washed well with cold water. The filter is then punched and the precipitate washed into a small clean beaker, the portion adhering to the sides of the flask dissolved in HCl, which is poured on the filter and the filter cleared from any Fe_2O_3 by HCl and thorough washing with hot water.† If sufficient HCl has not been used in clearing out flask and washing filter, enough is now added to dissolve all the Fe_2O_3, Cr_2O_3, $BaCO_3$ in the beaker, the solution diluted, boiled and the Fe_2O_3 and Cr_2O_3 precipitated by NH_4HO, the boiling being continued until all smell of NH_4HO has disappeared. This precipitate is filtered and washed thoroughly with hot water to get rid of all $BaCl_2$; dried and transferred to a platinum crucible, carefully separating the filter, which is ignited and the ashes added to the precipitate (which should not be heated). A mixture of three grams Na_2CO_3 and one-half gram KNO_3 is now added, and the whole fused carefully, the heat being raised gradually until all the KNO_3 is decomposed. After cooling, the fused mass is treated with hot water, and the soluble portion containing the Cr as alkaline chromate, with the excess of the alkalies, separated from the Fe_2O_3 by filtration, the precipitate and filter being thoroughly washed with hot water. The filtrate is acidulated with HCl, and evaporated to dryness with a little alcohol; when thoroughly dry, the Cr_2O_3 is dissolved in HCl, diluted and filtered from silica, the Cr_2O_3 precipitated by NH_4HO, filtered with the usual precautions, ignited and weighed as Cr_2O_3,* calculated to Cr by the factor 0·6853. Atomic weight of Cr 52·2.

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* It is almost impossible to buy $BaCO_3$ free from $BaSO_4$, the very best brands containing from 5-30 p. c. of $BaSO_4$. I prepare my own by dissolving $BaCl_2$ in water, filtering, adding large excess of NH_4HO and passing CO_2 into solution until all the barium is precipitated as $BaCO_3$, washing thoroughly, drying, and grinding in water to the consistency of cream.

† If it is desired to determine the chromium soluble in dilute HCl alone, or separately from that which remains in the insoluble residue, the filter should not be punched, but the Fe_2O_3, Cr_2O_3, and $BaCO_3$, dissolved on the filter, in dilute HCl and a separate determination made of the Cr in the insoluble residue (which remains on the filter) by burning the filter and fusing with Na_2CO_3 and KNO_3.

The only impurity this precipitate can contain is a little Al_2O_3, partly from the Al in the steel, and partly as an impurity in the Na_2CO_3 and KNO_3. The best method for separating this impurity, is to add to the solution of alkaline chromate obtained above (after fusion and filtration from Fe_2O_3) an excess of $KClO_3$, then a slight excess of HCl, and evaporate to syrupy consistency on the water bath, adding a little $KClO_3$ from time to time, so that there may always be an excess to decompose any HCl. Redissolve in water, add a slight excess of $(NH_4)_2CO_3$, and boil off all smell of the latter, filter, wash with hot water, add to solution an excess of HCl and, after the greater part of the $KClO_3$ is decomposed, a little alcohol, and precipitate the Cr_2O_3 as before.† In Genth's method (loc. cit.) of evaporating the solution of alkaline chromate nearly to dryness on the water bath, with an excess of $(NH_4)NO_3$, a minute amount of CrO_3 is reduced to Cr_2O_3, and precipitated; it is consequently filtered off with the Al_2O_3, SiO_2, etc., and lost, unless this residue should be treated separately to regain this Cr_2O_3, which very much complicates the process. If in the filtrate so obtained the CrO_3 is precipitated by $HgNO_3$ as Hg_2O, Hg_2CrO_4, some of the chromium salt nearly always passes into solution upon filtering, and can be detected, sometimes in very considerable amounts, in the filtrate. The same thing occurs if this method of precipitation is used, after neutralizing the solution of alkaline chromate (obtained by fusion with Na_2CO_3 and KNO_3, and filtering from the Fe_2O_3) by HNO_3. In all cases I have obtained the most satisfactory results by reducing the CrO_3 to Cr_2O_3, precipitating by NH_4HO, and weighing as Cr_2O_3.

This method for estimating chromium in steel may appear a little tedious, but quite a number can be made at once and only about three to four days is required for a complete estimation. The accuracy is all that can be desired and the delicacy of the method in detecting and estimating very small amounts, greater than that of any method I have used. I think I can safely say that it is delicate to 0·005 per cent of Cr. The amount of Fe_2O_3 usually precipitated by the $BaCO_3$, with the Cr_2O_3 is about 0·05 gram.

For techinal work the method can be very much shortened by fusing the precipitate by $BaCO_3$, with Na_2CO_3 and KNO_3 or

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* For precautions necessary to free Cr_2O_3 from alkaline salts, see Genth in Chem. News, vi, 30. Fres. Chem. Anal. Quant., 387.

† Dexter's method, see Rose, Chim. Anal. Quant., p. 520. Fresenius, Chem. Anal. Quant., p. 372. Pogg. Anal., lxxxix, 142.

$KClO_3$ (when $KClO_3$ is used instead of KNO_3 the precipitate must be thoroughly ground in and incorporated with the flux before fusing) dissolving in water, filtering, and determining the CrO_3 volumetrically. The results obtained in this way are fairly good, but are apt to be a little low.

Aluminium, nearly always exists as such in steel, and may be estimated with great accuracy by proceeding exactly as in the above method for the determination of chromium, until after filtering and washing the precipitate by $BaCO_3$, which is then dissolved on the filter in dilute HCl and the solution allowed to run into a small clean beaker. This solution is diluted, boiled, and the barium precipitated by a slight excess of dilute H_2SO_4; the $BaSO_4$ allowed to settle, filtered, washed, and the filtrate evaporated nearly to dryness to get rid of the excess of acid. This solution is then diluted, and the Fe_2O_3, and Al_2O_3 separated by $C_4H_6O_6$, NH_4HO, and NH_4HS. If the steel contains any chromium it will be with the Al_2O_3, and must be separated by fusing the residue obtained by running to dryness the filtrate from the FeS and igniting with Na_2CO_3, and KNO_3; dissolving in water and, without filtering, adding $KClO_3$ and HCl, as before in the separation of Al_2O_3, and Cr_2O_3. The Al_2O_3 obtained on precipitating by $(NH_4)_2CO_3$ will be contaminated by small amounts of SiO_2, and CaO (from the $C_4H_6O_6$) from which it can be separated by dissolving on the filter in HCl, after washing free from alkaline chromate, into a small clean beaker, running to dryness to render SiO_2 insoluble, dissolving. in HCl, filtering, and precipitating the Al_2O_3 by NH_4HO, being careful to boil off all smell of NH_4HO. After filtering and careful washing the precipitate can be dried, ignited, and weighed as Al_2O_3, calculating to aluminium by the factor 0·5331. Atomic weight, 27·4.

The great solubility of the Cr of chromium steel in the most dilute HCl certainly seems to indicate the existence of a true alloy of iron and chromium, and that a large part at least of the chromium exists as such, and not as an oxide or in any intermingled slag. Mr. E. Riley,* at a meeting of the Chemical Society, March 15, 1877, presented some specimens of chromium pig-iron containing from six to seven per cent of Cr. He mentioned the fact, during his remarks, that the Cr had dissolved with the Fe in the course of analysis. The president, Professor Abel, F.R.S., said that he had examined a specimen of the so-called chromium steel, but had found a mere trace of chromium in it. It was possible however, he said, that the chromium exerted a function in the production of the steel, but was eliminated at some stage in the process, so that it did not appear in the finished steel.

* Chemical News, No. 904, March 23, 1877.

In this connection the following analyses may not prove uninteresting, showing as they do that, in some cases at least, the chromium does "appear in the finished steel."

Sulphur,	0·005	per cent.	trace		trace	
Phosphorus,	0·021	"	0·020	per cent.	0·005	per cent.
Silicon,	0·129	"	0·189	"	0·279	"
Total carbon,	0·825	"	0·935	"	1·199	"
Comb. carbon,	0·811	"	0·920	"	1·186	"
Graphitic carbon,	0·014	"	0·015	"	0·013	"
Manganese,	0·245	"	0·062	"	0·039	"
Copper,	0·007	"	0·010	"	0·005	"
Nickel,	trace		0·023	"	0·021	"
Cobalt,	0·016	"	trace		0·018	"
Aluminium,	0·034	"	0·029	"	0·026	"
* Chromium,	0·651	"	0·223	"	0·916	"
Chromium, soluble,	0·615	"	0·212	"	0·899	"
Chromium in residue,	0·021	"	trace		trace	
Slag,	0·320	"				

The determinations of Cr marked * were made by the first method without the separation of Al, and consequently are a little higher than the sum of the "chromium soluble in dilute HCl," and "chromium in residue," which were determined in the portion and by the method taken for estimation of Al.

The "slag" in the first analysis given above, was determined by the "iodine" method and contained by analysis Fe_2O_3 0·110 per cent, Cr_2O_3 0·160 per cent, undetermined 0·50 per cent, total 0·320 per cent.

Laboratory of U. S. Board appointed to test Iron, Steel, etc.
Watertown Arsenal, Mass., April 14, 1877.

Art. XLVI.—*On the Chemical Composition of Triphylite, from Grafton, New Hampshire;* by Samuel L. Penfield. *Contributions from the Sheffield Laboratory of Yale College.* No. XLVII.

The rare mineral species, triphylite, is found at Grafton in a granite vein which has been extensively worked for mica. It occurs imbedded in the granite in masses of varying size, and occasionally of fifty or more pounds in weight. The exterior of the masses in some instances shows evidences of the decomposition to which the mineral is peculiarly liable, but a large portion of the material is fresh and unaltered. It has a light blue color, a greasy to resinous luster and a perfect cleavage. Specific gravity =3·52. Analyses of the finely pulverized, pure mineral, dried over sulphuric acid, show the following composition:

	I.	II.
P_2O_5	44·18	43·88
FeO	26·09	26·38
MnO	18·17	18·24
CaO	·89	·99
MgO	·56	·61
Li_2O	8·77	8·81
K_2O	·32	·32
Na_2O	·16	·09
H_2O	1·47	1·47
	100·61	100·79

The phosphoric acid was separated from the iron and manganese by fusion with sodium carbonate, except a small amount retained with the iron, which was separated afterward by means of molybdic acid.

The alkalies were separated from the iron and phosphoric acid by adding a small amount of ferric chloride to a nearly neutral, oxidized solution of the mineral and precipitating the iron and phosphoric acid together by means of barium carbonate. Care was taken to use platinum vessels in conducting the evaporations. The total amount of water was expelled by ignition and determined by absorption in a chloride of calcium tube. Water amounting to 0·50 per cent was driven off at 100° C. These results show the Grafton mineral to be richer in manganese and lithia than that from Bodenmais.

The relative number of atoms calculated from analysis 1 are the following:

P	·622				6·22
Fe	·362	·648			6·48
Mn	·256				
Ca	·016				
Mg	·014				
Li_2	·292	·297	Li	·584	·594
K_2	·003		K	·006	
Na_2	·002		Na	·004	
		·945			

The above gives the ratio of the phosphorus to the bases $= \cdot 622 : \cdot 945$ or $1 : 1 \cdot 52$, which shows the composition of the mineral to be that of a normal phosphate. The ratio of the atoms of the univalent elements to those of the bivalent is $\cdot 594 : \cdot 648 = 1 : 1 \cdot 09$ which gives the formula $10\overset{I}{R}_3PO_4+11\overset{II}{R}_3P_2O_8$. Rammelsberg* deduces the formula $4\overset{I}{R}_3PO_4+5\overset{II}{R}_3P_2O_8$ from the most trustworthy analysis of the Bodenmais mineral, but suggests $\overset{I}{R}_3PO_4+\overset{II}{R}_3P_2O_8$ as possibly the true formula. The

* Mineralchemie, 1875, page 307.

composition here obtained for the Grafton triphylite renders it almost certain that this is the correct formula of the mineral. This work was conducted in the Sheffield Laboratory under the supervision of Professor O. D. Allen, to whom I wish here to express my thanks.

ART. XLVII.—*On a new Mode of Manipulating Hydric Sulphide;* by JOSIAH P. COOKE, Jr., Erving Professor of Chemistry and Mineralogy in Harvard College.*

IN chemical laboratories, where instruction in qualitative analysis is given to large numbers on the class system, the use of hydric sulphide gas as a reagent is attended with grave inconveniences. These evils can in great measure be avoided by substituting for the gas a solution of the reagent in water, saturated at the ordinary temperature and pressure of the air; when, as is well known, one volume of water dissolves about 3·4 volumes of the gas (measured at 15° C. and seventy-six centimeters). Such a solution was for a long time used in the laboratory of Harvard College. It was prepared in a long series of two liter bottles connected by glass tubes in the usual way, and the solution was kept in the laboratory in a large tubulated glass flask, from which it was drawn by the students, as occasion required. This solution answers almost every purpose for which the reagent is used in the ordinary course of qualitative analysis, and the few conditions under which it does not give satisfactory results can be easily avoided. Moreover, in ease of application and promptness of effect it has all the advantages of a liquid reagent; and the only inconveniences its use involves is an occasional evaporation of a solution, which the dilution by the reagent may render necessary. Of course a solution of hydric sulphide is liable to oxidation, and soon becomes turbid in contact with the air; but this change can be easily avoided by fitting to the neck of the flask (in which the solution is kept), by means of a rubber stopper, a glass tube dipping under the liquid, and connecting this tube with one of the vents of illuminating gas in the laboratory.

For quantitative work, and for the preparation of chemical products, when considerable quantities of metallic sulphides must be precipitated, a solution of hydric sulphide, saturated under the ordinary pressure of the air, is inconveniently dilute; and two years since we described a simple method by which a solution concentrated under pressure could easily be prepared with the ordinary laboratory appliances. A heavy glass bottle of about four liters' capacity served as a generator, and from this the gas passed through a wash-bottle into two other bottles of the same size and strength as the first. The intermediate bottle was three-fourths filled with water, while the last served simply as a gasholder. The connections were so arranged that the gas, after bubbling up through the water, was delivered at the top of the gasholder; and, by a tube uniting the bottom of the gasholder with the water-pipes of the laboratory, the interior of the apparatus could be submitted to the pressure of a column of water sixty feet high. The gasholder was also provided with an exit tube, which could be closed by a compression cock. The connecting tubes all passed through rubber stoppers which were firmly wired to the necks of the bottles, and the water-bottle was connected with its neighbors by two lengths of stout rubber hose so that the water could be shaken up with the gas without disturbing the rest of the apparatus. In order to saturate the water with hydric sulphide, a charge of ferrous sulphide, sulphuric acid and water sufficient to yield at least three times the amount of gas theoretically required was placed in the generator, and, after the connections were made, the gas was allowed to steam through the apparatus until all the air was displaced. The exit tube of the last bottle was then closed, the water pressure turned on and the water-bottle frequently shaken, until absorption ceased, and the aqueduct water—at first forced by its pressure into the gasholder—was driven back into the pipes. Before dismounting the apparatus, the rubber connectors were all closed by compression cocks, and care was taken to vent the generator gradually. Moreover, the connectors of the water-bottle were so arranged that when the apparatus was dismounted a short piece of rubber hose was left attached to each orifice of the bottle, both of which were closed by compression cocks. To one of these a vent tube was subsequently attached, and by this the solution was drawn off at pleasure, as from a soda-water siphon.

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* From the Proceedings of the American Academy, vol. xii (N. S. iv), p. 113, 1877.

This simple apparatus was constantly used by us for two years, and served an excellent purpose; but it was found that after the glass generators had been charged several times they were liable to burst under the same pressure which at first they had readily sustained. The same accident never happened to the other bottles. But of course, if the pressure is long continued, bottles of glass of the size named, however well made, would be liable to such an accident; and, if the apparatus is to be remounted, it would be better to use a metallic vessel for the generator, and to cover the glass bottles with some kind of netting. The experience with the glass apparatus led us to seek to adapt to the same purpose some one of the various soda-water apparatuses which are greatly used in the United States for the production of effervescing drinks. After examining several of the patterns in the market, we selected for trial the one represented below, which is manufactured by the firm of John Matthews, of New York, at their establishment,—First Avenue, 26th and 27th Streets,—in that city. The apparatus was designed by them for preparing that overcharged aqueous solution of carbonic dioxide, which in the United States is familiarly called soda-water; but with a very slight modification it can be used with equal efficiency for the preparation of a similar solution of hydric sulphide. We have worked out the details of the process, which this new application involves, and publish them with the hope that the apparatus may be found of as great value in other laboratories as in our own. The wood-cuts are taken from the catologue of the firm, who have kindly loaned the blocks for this paper; and we would here express our obligations to them for their great courtesy and liberality during the whole course of our experiments.

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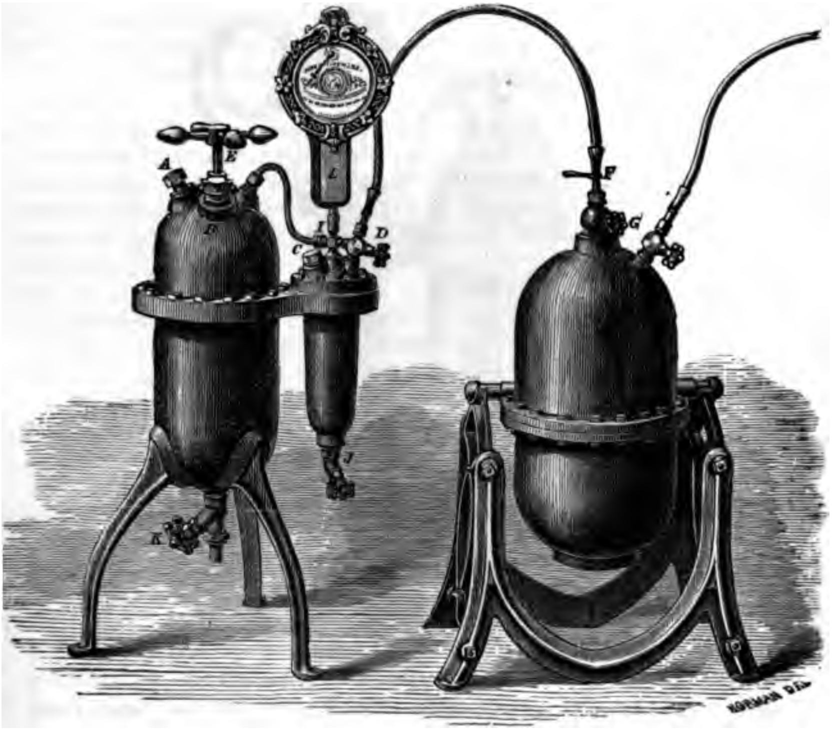

The apparatus consists of two parts, the generator and the fountains; and in Fig. 1 the generator is represented connected by a rubber hose with one of the fountains, of which in practice we use three, connected in a line by similar lengths of rubber hose, like so many Woolf's bottles. In the figure, only the first of the line is represented, which is set on trunnions in a frame, in order to facilitate the agitation of the water and the gas. Only one of these frames, however, is required, to which the other fountains can readily be transferred. A section of the generator is represented in Fig. 2. It is made of cast iron, and in two parts (readily distinguished in the figure), which are firmly bolted together, so as to confine in its place the bell-metal plate M, which separates the upper from the lower chamber. In the lower chamber is placed dilute sulphuric acid, which is poured in through the bung A. In the upper chamber, and resting on the plate, is placed coarsely powdered sulphide of iron, which is put in through the bung B. Through the plate M, and on two lines at right angles to each other, there are cut radial slits, half an inch wide, which are guarded by four iron arms. These arms are attached to the agitator shaft S, and move over the surface of the plate, alternately

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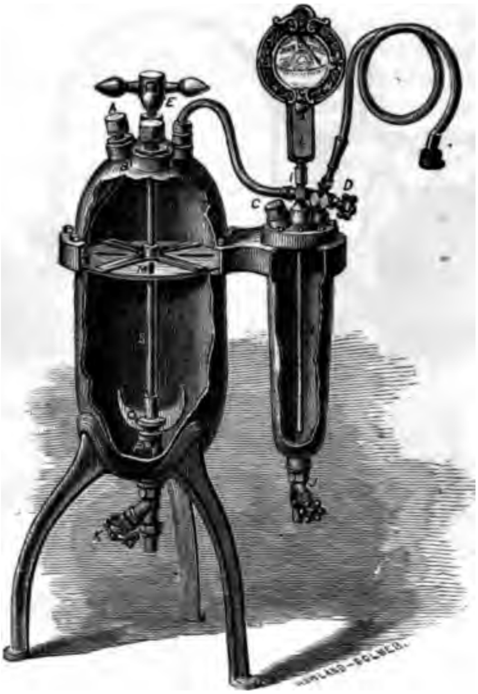

covering and uncovering the slits, when the handle E is turned. To the lower end of the same shaft is fastened the agitator O, which is turned simultaneously with the arms just mentioned. After the apparatus has been charged, it is evident that by turning the handle the sulphide of iron may be sifted down at pleasure into the acid water below; and the handle and arms are so disposed that when the bungs are uncovered by the handles the slits are covered by the arms. From the generator, the gas passes through the washer R, whose relations to the apparatus, as well as that of the pressure gauge, are evident from the figure. The generator is lined with lead, and the rest of the apparatus, including the bell-metal plate M, with pure tin. The lead lining of the generator is seamless and very heavy, and all the cocks are lined with block tin tubing. Of the various valves, bungs, and stuffing boxes indicated in the figure, it is unnecessary to speak in detail. It is sufficient to say that they are of excellent workmanship, and during a year's trial have kept perfectly tight. The charging bung, B, however, is closed by a safety cap of peculiar construction, which deserves special mention, because it insures the safety of the apparatus. The cap is represented by Fig. 3, and a section is given in Fig. 4.

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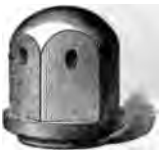

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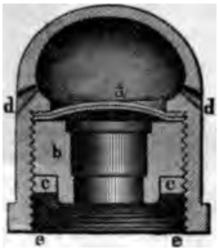

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It will be seen by the last that the escape of the compressed gas from the generator through the apertures *d* is only prevented by a thin disk *a*, which is shown in detail by Fig. 5. This disk is made of two thin plates: the lower one, which comes in contact with the acid spray, is of lead, and the upper one of silvered copper, whose thickness is so adjusted that it must be at once ruptured if the pressure in the apparatus should become unduly great.

Although the so-called soda-water fountains—in which the solution of the gas and water is made—have all in general the same simple relation of parts, they are constructed of very different materials and after very different methods. The outside shell may be either of hammered copper or of some form of iron, and this may be lined with tin, enamel, or glass. After having determined by experiment that a solution of hydric sulphide—especially when some carbonic dioxide is added—exerts no action on a surface of metallic tin, except a very slight and superficial staining, we selected as best adapted to our purpose the steel fountains, also manufactured by the firm of John Matthews, Fig. 6. These are made of plates of steel

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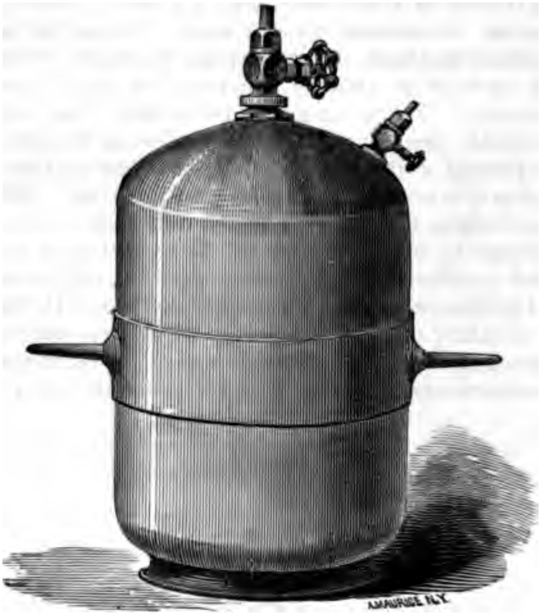
AMAURICE N.Y.

united in a peculiar way invented by themselves so as to secure with comparative lightness very great strength. They are lined on the inside with sheet tin, and the tin lining forms an independent vessel, which alone is connected with the bungs. The tubes and valve cocks are also either made or lined with tin, so that the solution never comes in contact with any other metal. For making ordinary soda-water, the fountain requires only a single valve, which connects with a tube leading to the bottom of the vessel, and this serves both to charge the fountain and to draw off the solution when made. But since a solution of hydric sulphide is rendered turbid if left in contact with even a small quantity of air, and since a variable amount of free hydrogen is always formed by the action of sulphuric acid on common sulphide of iron, it was necessary for our purpose to add to the ordinary fountain a vent cock as shown in the last figure. This enables us to connect together several fountains after the manner of Woolf's bottles, as already described, and, by passing the current of gas through the whole line, to drive out all the air originally in the apparatus, as well as the free hydrogen subsequently evolved. Moreover, in the preparation of the solution of hydric sulphide, the generator should be much larger relatively to the fountains than in the preparation of soda-water. Thus we use for charging the so-called six-gallon steel fountains, the "Upright Generator," known as No. 40, which has a capacity below the diaphragm of sixty liters. It should be here stated that the fountains are only rated at two-thirds of their total capacity, which is the volume of soda-water which is ordinarily made in them. They should never be more than three-fourths filled with water. But, even with this liberal allowance for gas room, the six-gallon fountains referred to will hold twenty-five liters of water. It may also be stated, although the fact must be evident, that a single large fountain will not give as good results as several small ones of equal capacity; since in expelling the air and free hydrogen, as we have described, there would be a considerable loss of material, if only one fountain were used. Still, in laboratories where the consumption is not great, the loss is not important; and the smallest "Upright Generator," with one six-gallon fountain, will be found to be a perfectly satisfactory apparatus.

Assuming first that the larger apparatus is used, the method of charging is as follows: The large generator is too heavy to be readily moved, and should be placed so that the discharge valve will empty directly into a drain. Water also should be brought to the apparatus by hose,—if possible, both hot and cold water,—not only for convenience in charging, but also in washing. Finally, there ought to be a good flue in the neighborhood, into which the waste gas may be discharged. The apparatus having been thus established, the three fountains—first rinsed out—are filled each with twenty-five liters of distilled water, and the valves having been secured, the fountains are connected with each other and the generator by means of stout rubber hose as already indicated, and the vent valve of the last fountain is connected with the flue by a length of common gas hose. The generator is then charged as follows: The handle is first placed so as to uncover the bungs and cover the slits in the diaphragm. Through the bung A is now poured forty liters of *hot* water, heated to between 70° and 80° C., and then five liters of common oil of vitriol are poured very cautiously into the same bung through a lead funnel with narrow spout provided for the purpose. The acid water will thus be heated nearly to the boiling point, and its capacity of dissolving ferrous sulphate raised to the maximum. Next six kilograms of sulphide of iron—previously sufficiently pulverized to pass through a wire sieve with eight meshes to the inch, and mixed with two kilograms of marble powder—is run through a wide-mouth funnel into the bung B. The bungs having been now all closed, the joints of the apparatus tested, the exit valve D of the generator and all the valves of the fountains opened. a small amount of the powder is sifted down into the acid water by turning the handle not more than a single revolution, always taking care to leave it so that the slits of the diaphragm shall be left covered. The gas is then allowed to stream through the apparatus, and tested as it escapes into the flue, until it burns without explosion, using a small pneumatic trough for that purpose. The air is now nearly expelled, and the escape of gas should be reduced by the last vent valve until the current only supplies a small jet, which may now be attached and lighted with safety, and by the size of this flame the vent may afterwards be regulated. The handles are now slowly turned, and the pressure in the apparatus carried up to about 120 pounds. The valves of the fountains and the valve D of the generator are now all closed, and the two last fountains detached, leaving the first (which is mounted on a frame as represented in Fig. 1) united to the generator as before. This is now rocked for several minutes to and fro, in order to thoroughly agitate the water with the gas. The stop valve G should then be opened, and then the valve D (very gradually), so that the gas may be admitted slowly to the fountain. The valves are then again closed, and the agitation renewed, and the same operation is repeated several times until no more gas is absorbed by the water in the fountain, the pressure in the generator meanwhile being maintained at 120 pounds, by turning the handle. The first fountain is then removed, and the same process repeated with each of the others. At the close of the operation, after all chemical action has ceased, there remains in the generator—both free and dissolved in the liquid residue—a large volume of hydric sulphide gas. This we economize by venting the generator slowly through Woolf's bottles containing aqua ammonia, and thus preparing at the same time ammonic sulphide. It is not unimportant to add that the generator should be emptied before it cools, and the ferrous sulphate has time to crystallize. The discharge valve R should then be removed, and the whole apparatus thoroughly washed out. If the valve becomes clogged, it can generally be cleared by developing pressure in the generator by means of a small charge of ground marble. Otherwise, after the pressure has been relieved, and the upper valves and bungs closed, the discharge valve must be cautiously removed, and an opening forced through the lower bung. Such details are necessary in order that others may profit by our experience; but, lest the details should convey the impression that the apparatus is complicated, and that the process requires skilled labor, it may be stated that in this laboratory the apparatus is entirely in charge of a laboratory servant, and may be managed by any workman of ordinary intelligence. It does not require more than four hours to work over a single charge, and this yields seventy-five liters of hydric sulphide solution under a pressure of 120 pounds. According to our experience, this supply lasts with a class of one hundred students in qualitative analysis about a month. For laboratories where the classes are much smaller than this, we should recommend the smallest size generator, which may be used with a single six-gallon fountain. The smaller apparatus is managed in precisely the same way as the larger, only taking one half the quantity of materials. It is important as before to wash out in the first place all the air, and to maintain a small current of gas through the vent valve of the fountain while the pressure in the apparatus is rising. This of course entails some loss of hydric sulphide; but the chief loss is caused by the venting of the generator, and all this gas may be utilized for the preparation of alkaline sulphides as described above, or this waste gas may be used for washing out the air from a second fountain, and thus preparing it for a subsequent charge.

For dispensing the reagent in our *qualitative* laboratory, we place the fountain in a cupboard and connect it by a block-tin tube with a so-called "draught column," Fig. 7, in the ventilating hood above. From this each student draws the reagent as it is required. In quantitative work we may draw the charged water directly from the fountain into the midst of the solution to be treated, using simply a common rubber hose terminated by a glass tube which dips under the surface of the liquid: the hose is attached to the nipple of a cap which screws on to the valve of the fountain, and by confining two or more disks of linen cloth between the cap and the head of the valve (like washers) we can filter the solution as it flows out. It is more convenient, however, to distribute the reagent to advanced students in the well-known soda-water siphon, Fig. 8. These require no description, but as the simple apparatus used for filling the siphon is not yet a familiar object in chemical laboratories, we give a figure of the apparatus (Fig. 9), taken, like our other cuts, from the catalogue of John Matthews. By

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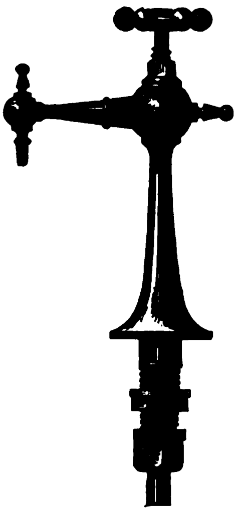

pressing the foot on a pedal shown at the base of the apparatus, the siphon—confined in a cage—is raised, so that its mouth is forced tightly against one opening of a valve of peculiar construction, the second opening of which is united by a block-tin tube to a fountain; while at the same time the handle of the siphon is pressed back. On now pushing the upper lever shown in the cut to the right, the valve of the fountain having been previously opened, a connection is made between the fountain and the siphon; when the charged water rushes into the latter, condensing the air to a fraction of its original volume. If next the same lever is pushed momentarily to the left, the first connection is closed; while a vent is opened, through which the condensed air rushes out into the atmosphere before the gas in solution has time to escape, and then on pushing back the handle a further portion of liquid enters, nearly filling the interior of the bottle. Lastly, on raising the *foot*, the valve of the siphon shuts at the same time that the

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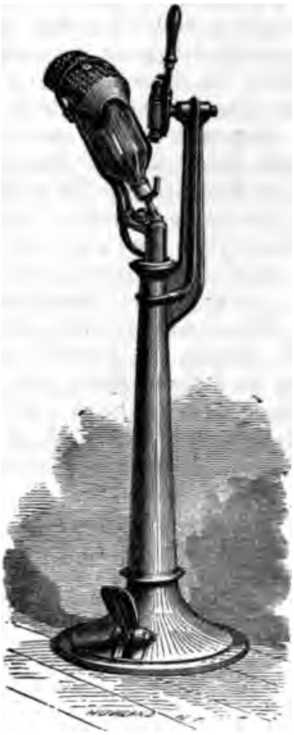

bottle is lowered and released from its cage,—the whole process being the work of a few seconds. At the first filling, there sometimes remains a small amount of air in the siphon, so that the solution becomes slightly turbid on standing; but this effect of oxidation can be easily avoided by using a sufficient amount of marble powder in charging the generator. This siphon unquestionably affords the most convenient mode of using hydric sulphide; and for a private laboratory a single siphon, well charged, will afford as ample a supply as will ordinarily be needed. It is greatly to be hoped that our manufacturing chemists may soon find an advantage in supplying this important reagent in such an elegant form.*

When the water is charged as directed above, it of course holds in solution, besides hydric sulphide, a considerable volume of carbonic dioxide; and if, under any circumstances, the presence of this last gas would produce an injurious effect, the marble powder can be simply omitted in charging the generator. In almost all cases, however, the carbonic dioxide exerts a very beneficial influence, and in several ways. In the first place, it insures the non-action of the hydric sulphide on the metallic surfaces of the apparatus. In the second place, it protects the solution from the action of the air when it is drawn into an open vessel, so that after a metallic sulphide has been precipitated by an excess of the reagent, the products may be digested in an open flask or beaker without fear of oxidation. In the third place, the carbonic dioxide adds greatly to the tension of the confined gas, and enables us to develop sufficient pressure to charge the siphon without unnecessarily increasing the strength of the solution of hydric sulphide.

Chemical Laboratory of Harvard College, 1876.

ART. XLVIII.—*Report on the Physical Investigations carried on by P. Herbert Carpenter, B.A., in H.M.S. "Valorous" during her Return Voyage from Disco Island in August*, 1875; by WILLIAM B. CARPENTER, C.B., M.D., F.R.S.†

IN the first of the Serial Soundings taken by the "Valorous," nearly in the middle of Davis Strait and on the parallel of Godthaab, the bottom-temperature, at a depth of 410 fathoms, was 34·6° Fahr.; and the descent to this from a surface-temperature of 40° was nearly uniform—39°, 38°, 37°, 36° and

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* All the apparatus here described may be obtained from the firm of John Matthews, First Avenue, 26th and 27th Streets. New York, at very reasonable rates. Be careful in ordering to state the use to which the apparatus is to be put, with the caution that no silver plating or lead paint should be used upon it.

† Proc. Roy. Soc., vol. xxv, No. 173, p. 230, June 15, 1876.

35° being met with at almost equal intervals. There was here, therefore, no indication of any contrary movement of different strata of water, or of any special superheating of the superficial stratum. But the case was very different with the next much deeper sounding which was taken about a degree further south, but still toward the middle of Davis Strait: for there was here a surface-stratum of 45°, but of such extremely small thickness, that the isotherm of 40° was reached in about fifteen fathoms; from 40° to 38° the interval was nearly the same as in the previous sounding; but below 38° the descent was so slow that 37° was not reached until nearly 800 fathoms, and on the bottom at 1100 fathoms the temperature was still 36·4°. At the next station, latitude 62° 6′ N., longitude 55° 56′ W., (that is, another degree further south, and at about the same distance from the Greenland coast), a depth of 1350 fathoms was met with; the surface-temperature was still 45°; but the bottom-temperature was found to be 34·6°, as in the 410 fathoms sounding. The next temperature-sounding was taken nearly three degrees further south and five and one-half degrees to the west, namely, in latitude 59° 10′ N., longitude 50° 25′ W.; that is, a little to the south of Cape Farewell, but still six degrees to the west of it: here the surface-temperature was still 45°; but the bottom-temperature at 1,750 fathoms had sunk to 33·4°. Finally, a set of serial soundings was taken before rounding Cape Farewell, about a degree further south and four degrees east: the surface-temperature had then risen to 49°; but the isotherm of 40° was reached at about fifty fathoms, that of 39° at about ninety fathoms, and that of 38° at about 160 fathoms; while below this the descent of the thermometers was extremely slow down to the isotherm of 37°, which lay at about 1050 fathoms—becoming more rapid, however, beneath this, so that 36° was reached at about 1400 fathoms, 35° at about 1500, and 34·3° on the bottom at 1660 fathoms.

Now these phenomena seem to me to point very distinctly to the existence (1) of a superheated layer, which is slowly moving up Davis Strait, and gradually losing its excess of temperature as it proceeds north, as shown by the gradual approach of the isotherms to the surface; (2) of a neutral intermediate layer, 1,000 fathoms or more in thickness, marked out by the extreme uniformity of its temperature, which indicates its stationary condition; and (3) of a deep cold layer, which as clearly derives its low temperature from a northern source, as the uppermost stratum does from a southern, and which must, therefore, be in movement.

The temperatures at Station VI seem at first sight rather anomalous when compared with those of Stations VII–X—the isotherm of 37° here coming up within 200 fathoms of the surface, while at only a degree farther south it lies at nearly 800 fathoms; and a bottom-temperature of 34·6° being found at 410 fathoms at Station VI, while at Station VIII it is only reached at 1,350 fathoms. But the anomaly disappears when the rapidly increasing depth and the tendency of the coldest water to gravitate to the bottom are taken into account: for it appears, from the temperature-soundings taken further north toward Disco Island by the Swedish ship "Ingegera," that water as cold as this, and even much colder (31° being recorded in one instance), is there found at depths varying between fifty-eight and 185 fathoms; and it can scarcely be doubted that the water which is chilled by the more severe cold of Baffin's Bay is here flowing down the slope of Davis Strait. Again, it is at first sight an anomaly to find at Station VIII a bottom-temperature of 34·6° at 1,350 fathoms, while the bottom-temperatures both to the north and to the south of it are 34·6°; but this only shows that the coldest polar water is flowing south through some deeper channel, perhaps in the western half of Davis Strait.* And the same explanation applies to the yet more remarkable fact that a bottom-temperature of 33·4° was met with near the mouth of Davis Strait, when no such water was met with further north. But that even this does not carry down the coldest water of the Arctic basin, is obvious from the fact brought to light by the "Porcupine" temperature-soundings in the "Lightning Channel," (between the north of Scotland and the Faröe Islands), over a large part of whose bottom we found the temperature to range two degrees, or even more, *below* 32°.

The next temperature-sounding, taken on the 17th of August almost exactly in the meridian of Cape Farewell, and not quite two degrees to the south of it, gave, like No. IX, a bottom-temperature of 33·4° at 1,860 fathoms; so that it seemed pretty clear that this is the temperature of the coldest water that can find its way into the North Atlantic along either the west or the east coast of Greenland. And from the depth at which the isotherm 35° was found to lie in the 1660 fathoms serial sounding, it is obvious that the stratum between 35° and 33·4° must be here a very thin one; while the upward slope which is indicated by the next sounding, shows that it must rapidly die out toward the east.

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* As I pointed out on a former occasion, (Proc. Roy. Soc., vol. xx, p. 624, § 144), any water moving from either pole toward the equator will have a *westerly* tendency in virtue of its *deficiency* of easterly momentum; just as water moving from the equator toward either pole will have an *easterly* set, in virtue of the *excess* of easterly momentum which it carries with it. The later temperature-soundings of the "Challenger" in the South Atlantic have given the explanation of the temperature of 32·4° observed under the equator in the first year of her voyage, but not encountered in any of the earlier temperature-soundings taken in the South Atlantic, by showing that the coldest Antarctic underflow is met with on the *westerly* part of its sea-bed.

The course of the "Valorous" having then been kept at first nearly due east, and afterward southeast, another serial temperature-sounding was taken on the 19th of August, in latitude 56° 11′ N., and longitude 37° 41′ W. The surface-temperature had here risen to 53°,—about the same as we had encountered in the "Lightning Channel," at the same time of the year, rather farther to the north; but the warm upper stratum was here thinner, a reduction to 45° taking place within fifty fathoms, and to 40° within 300; whereas in latitude 59° 35′ N., longitude 9° 11′ W., we had found the isotherm of 45° lying below 500 fathoms, while the bottom at 767 fathoms was still 41·4°. It is obvious moreover, from the regularity of the descent of the isotherm of 40° in this part of the North Atlantic, that *easting* has more influence on the rate of that descent than *southing*—thus confirming the view formerly expressed as to the tendency of the warm upper flow toward the *eastern* side of the basin.* The isotherms of 39° and 38° slope downward toward the east at about the same rate; but those of 37° and 36° still nearly keep their parallelism to the surface, confirming the previous suggestion of the "neutrality" of the deep stratum which they underlie.

Between the last station and the next, taken in latitude 56° 1′ N., and longitude 34° 42′ W., in the line of the channel between Iceland and Greenland, but considerably to the south of it, the sea-bed was found to have shallowed most remarkably, bottom being struck at 690 fathoms, and the bottom-temperature rising again to 38·2°. This elevation may be regarded with great probability as a continuation of that which was encountered by Sir L. McClintock in the line of temperature-soundings which he took several years ago across the North Atlantic between Rockall and Cape Farewell; for almost exactly in a line between the "Valorous" Station 13 and Iceland, Sir L. McClintock met with bottom at 743 fathoms, between 1,260 fathoms on the east and 1,159 fathoms on the west.

The course being now again kept nearly due east, another temperature-sounding was obtained in latitude 55° 58′ N., longitude 31° 41′ W., which, on a bottom of 1,230 fathoms, gave a bottom-temperature of 36·8°, the surface-temperature being 54·5°. Three degrees farther east, and on the same parallel, another set of serial temperatures was taken, which indicated a further increase in the upper warm stratum, the isotherm of 40° descending to about 880 fathoms; but the depths of the isotherms of 39°, 38° and 37° show little change; and the bottom at 1,485 fathoms was 36·5°, as at the corresponding depth on the other side of the ridge. Still farther to the east, in latitude 55° 10′ N., longitude 25° 58′ W., the depth was found to have still further increased to 1,785 fathoms; but the bottom showed no lower a temperature than 36·7°, although in the 1,750 fathoms sounding on the other side of the ridge the thermometer fell to more than *three degrees lower.*

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* Shearwater Scientific Researches, 1872, §§ 144, 148, (Proc. Roy. Soc., xx, pp. 624, 626).

Bad weather having come on, it was not considered prudent, in the disabled condition of the ship, to attempt further scientific explorations; and the course was accordingly shaped for Cork.

The Temperature-Section prepared from the serial soundings taken in the "Valorous" after quitting Davis Strait has been continued toward Valentia on the basis of the serial soundings taken off the coast of Ireland in the first cruise of the "Porcupine" in 1867, a sounding in 1,263 fathoms, latitude 56° 8′ N., longitude 13° 34′ W., being taken as the principal guide. This being almost on the same parallel with the last serial sounding of the "Valorous," (the difference of latitude being only half a degree), and the seasonal difference being rather in favor of the "Valorous" temperatures, it is extremely striking to find in this section the most remarkable contrast yet brought out between the thermal condition of the eastern and the western sides of the North Atlantic: for the descent of all the isotherms as they pass from west to east, which has been already pointed out in the "Valorous" portion of the section, continues at an even more rapid rate: so that the isotherm of 40°, which lay at Station XVI at 380 fathoms, lies at 900 fathoms at Station XVII, fifteen degrees to the west; while the isotherm of 45°, which at the first of these stations lay at eighty fathoms from the surface, lay in the second at 640 fathoms. This difference in the thickness of the whole stratum above the isotherm of 40° is much more remarkable than the difference of surface-temperature, the increase of which between the first and the second station was only from 55° to 59·6°.

It is clear, therefore, that the heating power of the warm flow which comes up from the southwest toward the western shores of the British Isles, and which proceeds onward to the northeast, so as to ameliorate the climate of the Orkneys and Shetland Islands, but still more markedly to affect that of the coast of Norway (as has been shown by Professor Mohn), depends upon *its great depth.* Any such superheated film as the Gulf-stream has been found to be when last recognizable as a current (as was long since urged by Mr. Findlay, and has since been confirmed by Capt. Chimmo's observations), must lose its excess of warmth long before it reaches our shores.

Hence, as I have urged on a former occasion, the prolonged heating power of the northeast flow depends much more upon the thickness of its moderately warm stratum than upon its bringing with it a high surface-temperature. A layer of fifty fathoms at 60°, flowing northeast over a bed of ocean-water at 40°, and exposed above to an atmosphere of 40°, would be cooled down to that standard in two or three weeks. But a layer of 900 fathoms thickness, ranging from 40° to 55°, would retain an excess of temperature far longer.

The advocates of the doctrine that the *vis a tergo* is the Gulf-stream, which cannot be traced as a current by any distinctive feature further to the northeast than the parallel of 40° and the meridian of 30°, have to show in what way it can raise the temperature of so thick a stratum of ocean-water as we have seen to be affected in the western portion of the North Atlantic by a warm flow of some kind. Whether, as Professor Wyville Thomson maintains, the approximation of its boundaries between the British Islands on one side and Labrador and Greenland on the other can possibly produce this result, is a point on which it is for hydrographers to decide. For myself, I cannot regard it as probable that a spent stream of fifty fathoms thickness can give motion to a vast layer of 900 fathoms depth.

On the other hand, the doctrine I advocate, that a thick upper stratum of the North Atlantic is slowly moving poleward, to fill up the void left by the gravitation-underflow of the coldest water toward the equator, and that this stratum will also have an easterly tendency in virtue of the excess of easterly momentum which it brings with it from a lower latitude, seems adequately to account for the facts now brought to light. The progressive closing in of the boundaries of this poleward upper flow will obviously tend to deepen it, so as to give it a more persistent heating power.* In the South Atlantic and Southern Indian Oceans, on the other hand, the progressive opening-out of the ocean-boundaries, as we pass southward from the equator, will tend in the same measure to reduce the thickness of the poleward upper flow, thus diminishing the persistence of its heating power. And in this, as it seems to me, we have the true explanation of the marked difference between the climate of Kerguelen's Land (latitude 50° S.), for example, or that of Heard Island (latitude 53° S.), and that of Ireland, (lying between the parallels of 51½° and 54½° N. latitude), the summer temperature of the former being but little above the winter temperature of the latter.

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* This position may seem inconsistent with the objection just taken to the doctrine of Sir Wyville Thomson. But the inconsistency is only apparent. I cannot conceive that after the Florida Current has spread itself out like a fan over the Mid-Atlantic, it can retain enough *vis a tergo* to give a northeast movement to a mass of water nearly 2,000 miles wide and 700 or 800 fathoms deep, the impelling force being progressively weakened by the obstacles to that movement. On the other hand, the force which (on the doctrine of a Thermal circulation) acts as a *vis a fronte*, grows stronger as the water which it puts in motion approaches the polar area, and thus is fully competent to deepen the poleward stratum in proportion to the reduction of its breadth.

The "Challenger" temperature-sections have most conclusively shown that the entire warm upper stratum in the South Atlantic is very much thinner than that of the North Atlantic; and while I fully admit that a part of this difference is due to the fact that a far larger portion of the equatorial current is deflected into the latter than into the former, I cannot see that the Gulf-stream by any means accounts for the descent of the isotherm of 40° in latitude 56° N. to a depth of 900 fathoms.

The "Valorous" temperature-soundings seem to me to be of peculiar interest and value, in furnishing a satisfactory explanation of the comparatively high bottom-temperature of the North Atlantic. I have always attributed this to the comparative narrowness of the channels of communication between the Arctic and the North Atlantic basins, which restrict the flow of the coldest polar water from the former into the latter; and long before the "Challenger" Expedition sailed, I had ventured the prediction that the South Atlantic, on account of the perfect freedom of its communication with the Antarctic, would have a colder bottom, and that the influence of the Antarctic underflow would probably extend to the north of the equator. By Sir Wyville Thomson, on the other hand, it was argued from the commencement that the whole cooling of the deep stratum of the *North* Atlantic is due to the *Antarctic* underflow; and this conviction he repeats in his last utterance on the subject, on the ground of the continuity of the isotherms from the South into the North Atlantic.* The question arises, however, why the deep stratum of the North Pacific, which is undoubtedly fed from the Antarctic, should be so decidedly colder, as the "Challenger" and "Tuscarora" soundings show it to be, than the deep stratum of the North Atlantic; and this question appears to me to find an entirely satisfactory answer in the indication furnished by the Second Section, that the Arctic Basin is for the most part separated from that of the North Atlantic by an intervening ridge, which (like many similar ridges discovered by the "Challenger") allows water of about 36°, but *not colder water*, to pass from the former into the latter. The limited contributions of colder water furnished by Baffin's Bay and the "Lightning Channel" would help to reduce the deep temperature of the North Atlantic generally to the 35°–36° shown in the "Challenger" Sections; but it is only when, on approaching the equator, a bottom-temperature below this first shows itself, that I can recognize the influence of the Antarctic underflow.

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* Proceedings of the Royal Society, vol. xxiv, p. 632.

I forbear, however, to discuss this subject more fully at present, the Admiralty not having yet published the final installment of the "Challenger" temperature-sections. And I shall confine myself to an expression of my earnest hope that the ship to be sent next year to communicate with the Arctic Expedition may have, as part of its work, the completion of that which the "Valorous" was disabled from performing—namely, the obtaining a continuous temperature-section between Iceland and Greenland, and another across Davis Strait.

ART. XLIX.—*On the Influence of Geological Changes on the Earth's Axis of Rotation*;[*] by GEORGE H. DARWIN, M.A., Fellow of Trinity College, Cambridge. Received by the Royal Society October 13, 1876.[†]

THE subject of the fixity or mobility of the earth's axis of rotation in that body, and the possibility of variations in the obliquity of the ecliptic, has of late been attracting much attention; but the author believes that it has not hitherto been treated at much length. The paper, of which the following is an abstract, is an attempt to investigate the results of the supposition that the earth is slowly changing its shape, with especial reference to the effects on the obliquity of the ecliptic and on the geographical position of the earth's axis of figure.

1. This part of the paper is devoted to the consideration of the precession and nutations of an ellipsoid of revolution which is slowly and uniformly changing its shape. The change is supposed to proceed from causes internal to the earth, and only to continue so long as the total changes in the principal moments of inertia C and A remain small compared to their difference, $C—A$.

The problem is treated by means of M. Liouville's extension of Euler's equations of motion of a rigid body about a point.[‡] By an approximate method these equations may be treated as linear, and the solution divided into two parts.

Let θ be the obliquity of the ecliptic; $\Pi \operatorname{cosec} \theta$ the precession of the equinoxes; $-n$ the angular velocity of rotation of the ellipsoid; $A+at$, $A+bt$, $C+ct$ the principal moments of inertia at the time t. Then it is shown that the secular effect on the obliquity of the ecliptic, as resulting from the motion of the principal axes in the body (which constitutes the first part of the solution), is given by the equation

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[*] Since this paper was in manuscript Sir William Thomson has delivered his address to the Mathematical Section of the British Association at Glasgow. He therein touches on this subject, and gives some of the results attained here; but as he has not stated how he has attacked the problem, and as the subject has been recently attracting much attention, the author still ventures to offer his paper to the Royal Society.

[†] Abstract of Mr. Darwin's Memoir, from the Proceedings of the Royal Society xxv, No. 175, 328.

[‡] Liouv. Journ., 2e série, t. iii, 1858, p. 1; Routh's Rigid Dynam, p. 150.

$$\frac{d\theta}{dt}=-\frac{\Pi}{2n}\,\frac{a+b-2c}{A};$$

and as resulting from the change in the impressed forces, due to the change of shape of the body (which constitutes the second part), is given by

$$\frac{d\theta}{dt}=\frac{\Pi}{2n}\,\frac{a+b-2c}{C-A}.$$

The former part may be neglected compared with the latter. But from such geological changes as we are entitled to assume in the case of the earth, the total change in the obliquity of the ecliptic must be exceedingly small. Even gigantic polar ice-caps during the Glacial period could not have altered the position of the arctic circle by so much as three inches; and this is the most favorable redistribution of matter on the earth's surface for producing that effect. Thus the obliquity of the ecliptic has remained sensibly constant throughout geological history.

It is also shown that, during any gradual deformation of the ellipsoid, the instantaneous axis of rotation will always remain sensibly coincident with the principal axis of figure.

In the course of the work by which the previous results are attained there is shown to be a small inequality in the motion of the instantaneous axis, in consequence of which that axis describes a circle with uniform velocity, and is coincident with the axis of figure every 306th day (in the earth). This circle touches the meridian along which the axis of figure is traveling in consequence of the deformation of the earth's shape. The diameter of the circle is shown in a particular case (not unfavorable to produce a large effect) to be less than $\frac{1}{378}''$. But although this inequality appears to be so small, it is of interest and is discussed at some length. It is shown that, if the earth be not quite rigid, this inequality might have the effect of modifying the path of the axis of figure in the body, in consequence of readjustments to a figure of equilibrium.

Various hypotheses as to the power of adjustment are considered, and the paths of the instantaneous and principal axes in the precession of a viscous spheroid undergoing deformation are found.

It is maintained that although the earth may be sensibly rigid to the tidally deforming forces exercised by the sun and moon, it would not be so to considerable departures from the figure of equilibrium, such as would arise from a wandering of the pole of figure from its initial position; and that readjustments to an approximate form of equilibrium probably take place, at considerable intervals of time, impulsively by means of earthquakes. Such periodical adjustments would not sensibly modify the geographical path of the principal axis as due to terrestrial deformation. But it is held that during the consolidation of the earth there must have been great instability in the geographical position of the poles. Throughout the rest of the inquiry, however, the hypothesis of the earth's sensible rigidity, together with the possibility of more or less rare impulsive readjustments to the figure of equilibrium, is adhered to. In consequence of these results dynamical considerations may be dismissed, and it only remains to consider the kinematical question of the change in the earth's principal axes due to any deformation of its shape.

2. Formulæ for this end are here found, and are adapted for numerical calculation. It is assumed, in the first place, that the deformation is such that there is no change in the strata of equal density; and accordingly all suppositions as to the nature of the internal changes accompanying geological upheaval and subsidence are set aside.

3. The forms of continent and depression are next investigated, which, for the transport of a given quantity of matter from one part of the earth's surface to another, would cause the maximum deflection of the principal axis of greatest moment—subject, however, to the condition that the layer excavated or piled up shall nowhere exceed a given small fraction of the earth's radius.

It is shown that the continents and depressions must be of uniform height and depth; there must be two of each, all similar to one another; that each has one of its own kind diametrically opposite to it; that they are in shape sphero-conics, formed by the intersection of a certain elliptic cone with the sphere; that the centers of the four sphero-conics are all on the same *complete* meridian and all in latitude 45°. A table of numerical results depending on the values of certain elliptic functions is given.

4. In this part an endeavor is made to collect evidence as to the extent to which the earth may have undergone deformation from geological changes. The object is to discover what are the largest areas over which there has been a consentaneous rise or fall, and what is the greatest vertical amount of that rise or fall; also to determine how the erosion of the land and the sea affect the local excesses or deficiencies of matter on the earth's surface. The areas and amounts of elevation and subsidence

which on a sealess and rainless globe are equivalent, as far as producing excesses or deficiencies of surface matter, to those which obtain on the earth are referred to as "effective;" and it is only the effective elevation or subsidence which we require to know in order to determine the shift of the earth's axis.

The evidence as to area is very meager, because precise boundaries to regions of elevation and subsidence cannot be assigned; but, *faute de mieux*, the author's father, Mr. Charles Darwin, marked out for him on a map an area in the Pacific Ocean which (on account of the structure of the coral islands) he believes to have undergone subsidence within a recent geological period. From a consideration of this and of other points the author believes that from $\frac{1}{18}$ to $\frac{1}{28}$ of the whole earth's surface may, from time to time, have undergone elevation and subsidence. The greatest vertical effective amount of rise or fall cannot be determined from geological evidence, because of the effects of erosion and of the influx of the sea into parts below the mean level of the earth.

The only way of determining the point seems to be to find what is the difference of mass, standing on unit area of the earth's surface, in an ocean of, say, 15,000 feet deep, and in land of, say, 1100 feet high. From this difference of mass the effective elevation of an ocean-bed in its conversion into land can be at once determined. Taking the above numbers, it is found to be 10,436 feet; and in the examples given in the following part, the deflection of the polar axis, for an assumed effective elevation of 10,000 feet, is given in each case.

It is then pointed out that, if the deformation of the earth were of very wide extent, the level surface of the sea would approximately follow the rocky surface, and that thus there might be sufficient change in the earth's shape to sensibly affect the position of the principal axis, without there being any geological signs of elevation or subsidence.

5. Numerical application is now made of the preceding work to the case of the earth, and, as before stated, all the results are given for 10,000 feet of effective elevation.

The first application is to continents and seas of maximum effect, and a table of results is given. It may be here stated that if $\frac{1}{260}$ of the earth's surface is elevated, the deflection of the pole is $11\frac{1}{3}'$; if $\frac{1}{26}$, 1° $46\frac{1}{2}'$; if $\frac{1}{16}$, 3° 17′; and if $\frac{1}{2}$, 8° $4\frac{1}{2}'$.* In each case an equal area is supposed to fall simultaneously.

Other examples are then given for continents and seas which do not satisfy the maximum condition; in some the boundaries are abrupt cliffs, in others shelving.

The conclusion is arrived at, that a single large geological produce an alteration in the position of the pole of from one to change, such as those which obtain on the earth, is competent to three degrees of latitude, on the hypothesis that there is no change in the law of internal density.

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* The area of Africa is about ·059, and of South America about ·033 of the earth's surface.

6. Various hypotheses as to the nature of the internal changes accompanying the deformation of the earth are discussed.

First, it is shown that if upheaval and subsidence are due to a shrinking of the earth as a whole, but to the shrinking being quicker than the mean in some regions and slower in others, the results are the same as those previously attained.

Second, the increase of surface matter due to the deposit of marine strata also gives the same results.

Third, the hypothesis that upheaval and subsidence are due to the intumescence or contraction immediately under the regions in question is considered. Under certain special assumptions, too long to recapitulate, it is shown that the previous results must be largely reduced. A table of the values of the reducing factor for various thicknesses of the intumescent strata is given; from which it appears that if the stratum is tolerably thin and at all near the surface, the deflection of the pole is reduced to quite an insignificant amount. Even if the intumescence extends right down to the center of the earth in a cone bounded by the elevated region, the results would be only about $\frac{2}{3}$ of the former ones. Hence it appears that the earlier results can only be stated as a superior limit to what is possible.

7. In conclusion it is pointed out that if the earth be quite rigid, no redistribution of matter in new continents could ever cause the deviation of the pole from its primitive position to exceed the limit of about 3°. But if the previously maintained view is correct, that the earth readjusts itself periodically to a new form of equilibrium, then there is possibility of a cumulative effect; and the pole may have wandered some 10° or 15° from its primitive position, or have made a smaller excursion and returned to near its old place. No such cumulation is possible, however, with respect to the obliquity of the ecliptic.

It is suggested that possibly the glacial period may not have been really one of great cold, but that Europe and North America may have been then in a much higher latitude, and that on the pole retreating they were brought back again to the warmth. There seem to be, however, certain geological objections to this view.

ART. L.—*On a Base derived from a Waste-product in the Aniline Manufacture;* by C. LORING JACKSON.

IN the spring of 1875 under the direction of Prof. A. W. Hofmann I investigated a waste-product from the factory of Drs. Martius and Mendelssohn-Bartholdy at Rummelsburg near Berlin, which was obtained after the toluidine had passed over in the annual rectification of the highest fractions from the aniline-oil distillation. The results I then obtained were published in the Berichte der Deutschen Chemischen Gesellschaft for 1875, page 968, and may be briefly restated as follows by way of introduction to my subsequent work.

The substance, a black oily liquid, was dissolved in strong hydrochloric acid, and freed from tar by repeated filtration; the oily base set free by sodic hydrate was then fractioned, and yielded at first xylidine and allied bodies which were not further examined; later a fraction from 280° to 320° which, after removal of naphtylamine with dilute sulphuric acid, was converted into a nitrate and purified by crystallization; it then formed radiated groups of white needles which gave on analysis:

	Calculated for $C_{13}H_{14}NNO_3$.	Observed.
Carbon	63·41	63·38
Hydrogen	5·69	5·66

By heating with nitric acid a magenta-colored substance was formed which rendered it very difficult to obtain the salt white.

The *sulphate* was very soluble.

The *chloride* $C_{13}H_{14}NCl$ crystallized in white flat needles.

The *platinum salt* $(C_{13}H_{14}N)_2PtCl_6$ crystallized in very characteristic fan-like groups of sparingly soluble light yellow needles often more than half a centimeter long. The analysis gave

	Calculated.	Found.
Platinum	25·36	25·39
Carbon	40·08	38·78
Hydrogen	3·59	3·82

The *free base* $C_{13}H_{13}N$ was obtained as an oil which gave with chloroform and potassic hydrate a smell similar to that of the isocyanides; it was therefore a primary amine, and its formula must be written $C_{13}H_{11}NH_2$.

An *acet-compound* $C_{13}H_{11}NHC_2H_3O$ was also prepared by the action of acetyl-chloride on the free base; it crystallized in white needles and melted at 114°·25. At that time also some attempts were made to obtain synthetically a base with the same formula, but the results were not published.

At the beginning of the next year, T. Carnelly* described a base $C_{13}H_{11}NH_2$ formed by the reduction of mononitrotolylphenyl made synthetically, but as he did not describe either the acet-compound or the platinum salt there were no data for a comparison of his base with mine; to furnish such data is the object of the present paper. Carnelly found that, on addition of sodic hydrate to a salt of his base and extraction with ether, on evaporating the ether "an oily body was first produced from which there separated out a small quantity of needle-shaped tufts. The melting-point of these after careful drying was found to be 93°–97°." Under the same conditions my base also furnished an oil, but at the time of the investigation in Berlin I observed no crystals. In the hope that longer standing would cause it to solidify I have since the publication of Carnelly's paper, precipitated the small quantity of the salts of my base still at my disposal with sodic hydrate and allowed the brown oil thus obtained to stand under a bell-jar; after several days crystals appeared, and in a few weeks it had changed nearly completely into good-sized prismatic crystals arranged in pennate groups which broke up on pressure into rough octahedral masses. Freed by means of filter-paper from a little adhering brown oil these crystals melted at 46°–70°; from an ethereal solution the substance separated as a brown oil solidifying on stirring to pennate plates with the same melting-point as before recrystallization. The crystals were insoluble in water, freely soluble in alcohol, ether and benzol, and instantly converted by hydrochloric acid into a chloride which dissolved easily in water and was obtained crystallized in white flattened needles two and a half centimeters long melting with partial decomposition near 200°, whereas Carnelly's crystalline base when heated with hydrochloric acid "dissolved only after long boiling; on cooling, small fine white silky needles were deposited, which were separated from the mother-liquor, washed with a little water and dried over lime, after which they were found to melt, with blackening, at 280° to 283°."

From this comparison it is evident that the base described by Carnelly is not identical but isomeric with that obtained by me, and this view is further confirmed by the fact that the fan-shaped crystal-groups of the platinum salt of my base were so characteristic that Carnelly would have certainly described them had his platinum salt appeared in this form.

Finally, it is worth mentioning that in 1875 I had, as announced at the end of my first paper, attempted to prepare synthetically a base with this formula, and even after the publication of Carnelly's paper, as my method was different from his, I determined to bring the experiments for which I had prorided material to a conclusion before abandoning the field to im; the work however was delayed by other and more important researches and it was not until this winter that I was eady to examine the products of the reaction of sodium on mixture of parabromanilin and parabromtoluol; just as I ad proved the absence of any base other than bromanilin I eceived the paper* Ueber eine neue Bildung des Azobenols by R. Anschuetz and G. Schultz and guided by it have ucceeded in detecting also the azobenzol. I can therefore conirm the results recorded in that paper in every particular.

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* Journ. Chem. Soc., II, xiv, 21.

To avoid interfering with any of the above-named gentleen I intend to abandon this line of research.

Chemical Laboratory of Harvard University, Cambridge, Mass., March 3d, 1877.

ART. LI.—*On an association of Gold with Scheelite in Idaho;* by B. SILLIMAN.

A CORRESPONDENT in Idaho has lately sent me a specimen, btained from a mineral vein, in which native gold is associated vith scheelite and quartz. On account of some resemblance in olor to grossular garnet, the miners mistook the scheelite for his species. But the high density of the mass at once attracts ttention and a trial for hardness alone proves it is not garnet. The pyrognostic characters also show the absence of silica and he presence of tungstic acid. The powdered mineral treated vith hydrochloric acid develops at once the characteristic yellow f tungstic acid, and zinc converts this solution to the familiar lue of tungstic oxide.

The gold appears in the scheelite, intimately associated with small amount of pyrite, interspersed in the mass of scheelite nd quartz. The pyrite is considerably decomposed, yielding ellowish-brown oxide of iron, and some green stains indicate lso chalcopyrite, traces of which are detected by close obserration. Leucopyrite is also present in minute quantities. But he total quantity of sulphides is certainly not over 1 to 1½ per ent of the mass, if so much.

The scheelite is massive, with few crystalline faces; its color s yellow-brown, resembling chondrodite. Portions of it are uite free from quartz or any mineral but gold. I found the ensity of the entire mass (weighing 379·42 grams) to be 3·27. Taking the density of quartz =2·66, and of scheelite =6, and lisregarding the minor constituents of the mass, the proportions f these two minerals is as 270 : 109·37, or 2·46 parts of quartz o 1 part of scheelite. This is doubtless much above the average amount of scheelite in the vein, as a whole, but the high density of the tungstate renders its separation from quartz by mechanical dressing an easy matter, and suggests this as a valuable resource for tungstic acid, the value of which in the form of sodic tungstate, for fire-proofing textile fabrics, is well understood. *Locality.*—Charity Mine, Warren's, Idaho Territory. My correspondent says: "The miners on this ledge (lode) lately struck a pocket of ore similar to that I send, and in a few evenings pounded out in a hand mortar about one thousand dollars, gold value, from a few candle boxes full of ore. The ore usually pays about twenty dollars per ton."

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* Ber. Deutsch. Chem. Gesellschaft, ix, 1398.

The affinities of mineral association indicate that cassiterite and wolfram may reasonably be looked for in the future exploration of this interesting vein.

Since writing the above, I have learned of another and much more interesting example of the occurrence of gold in scheelite, from Golden Queen Mine, Lake Co., Colorado. The gold is in minute crystalline granules in the scheelite and fills what appears to have been a geode of scheelite crystals.

New Haven, April 19, 1877.

ART. LII.—*Ninth Report of the British Association Committee, appointed for the purpose of investigating the Rate of Increase of Underground Temperature downward in various Localities of Dry Land, and under Water;* drawn up by Prof. EVERETT, Secretary of the Committee.*

A REMARKABLE series of observations have recently been taken in a boring at Sperenberg, near Berlin. The bore was carried to the depth of 4,052 Rhenish (or 4,172 English) feet, and was entirely in rock salt with the exception of the first 283 feet, which were in gypsum with some anhydrite. The observations were taken under the direction of Herr Eduard Dunker, of Halle-an-der-Saale, and are described by him in a paper occupying thirty-two closely printed quarto pages (206–238) of the Zeitschrift für Berg-Hütten-und-Salinen-Wesen (xx Band, 2 und 3 Lieferung, Berlin, 1872).

The instrument employed for measuring the temperature was the earth-thermometer of Magnus, which gives its indications by the overflowing of mercury, which takes place when the instrument is exposed to a higher temperature than that at which it was set. To take the reading it was immersed in water a little colder than the temperature to be measured; the temperature of this water is noted by means of a normal thermometer, and at the same time the number of degrees that are empty in the earth-thermometer is noted. From these data the maximum temperature to which the instrument has been exposed can be deduced, subject to a correction for pressure, which is not very large, because the same pressure acts upon the interior as upon the exterior of the thermometer.

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* The committee consisted of Prof. Everett, Sir W. Thomson, Prof. J. Clerk Maxwell, G. J. Symons, Prof. Ramsay, Prof. A. Geikie, James Glaisher, George Maw, W. Pengelly, Prof. Hull, Prof. Ansted, Prof. Prestwick, Dr. C. Le Neve Foster, Prof. A. S. Herschel, G. A. Lebour, and A. B. Wynne.

In the following *résumé* (as in the original paper) temperatures are expressed in the Réaumur scale, and depths in Rhenish feet, the Rhenish foot being 1·029722 English foot.

Observations were first taken at intervals not exceeding one hundred feet, from the depth of one hundred feet to that of 4042 feet, the temperature observed at the former depth being 11·0, and at the latter 38·5; but all these observations, though forming in themselves a smooth series, were afterward rejected, on the ground that they were vitiated by circulation of water and consequent convection of heat.

It has often been supposed that though this source of error may affect the middle and upper parts of a bore, it cannot affect the bottom; but the Sperenberg observations seem to prove that no such exemption exists. When the bore had attained a depth of nearly 3,390 feet, with a diameter of twelve inches two lines at the bottom, an advance bore of only six inches diameter was driven seventeen and one-half feet further. A thermometer was then lowered half-way down this advance bore, and a plug was driven into the mouth of this advance bore so as to isolate the water contained in it from the rest of the water above. After twenty-eight hours the plug was drawn and the thermometer showed a temperature of 36·6. On the following day the temperature was observed at the same depth without a plug, and found to be 33·6. Another observation with the plug was then taken, the thermometer (a fresh instrument) being left twenty-four hours in its position. It registered 36·5, and again, without plugging, it gave on the same day 33·9. It thus appears that the effect of convection was to render the temperature in the advance bore 3° R. too low.

Apparatus was then employed for isolating any portion of a bore by means of two plugs at a suitable distance apart with the thermometer between them. This operation was found much more difficult than that above described, but in several instances it gave results which were deemed quite satisfactory; while in other instances the apparatus broke, or the plugging was found imperfect. The deepest of the successful observations by this method was at 2,100 feet, and the shallowest was at 700 feet. The first 444 feet of the bore were lined with iron tubes, between which the water had the opportunity of circulating even when the innermost tube was plugged, hence the observations taken in this part were rejected.

All the successful observations are given in the third column of the following table, subject to a correction for pressure; and, for the sake of showing the error due to convection in the ordinary mode of observing, the temperatures observed at the same depths when no plugs were used, are given in the second column:

Depth in feet.	Temperature Reaumur.		Difference.
	Without plugging.	With plugging.	
700	16·08	17·06	0·98
900	17·18	18·5	1·32
1,100	19·08	20·8	0·72
1,300	20·38	21·1	0·72
1,500	22·08	22·8	0·72
1,700	22·9	24·1	1·2
1,900	24·8	25·8	1·0
2,100	26·8	27·1	0·3
3,390	34·1	36·15	2·05

These temperatures are not corrected for pressure, but they are corrected for rise of zero in the normal thermometer; and this last circumstance explains the difference of 0·4 between the temperature 36·15 here given and 36·55, which is the mean of the above-mentioned observations at the depth of 3,390 feet.

Another proof of the injurious effect of convection was obtained by comparing the observed temperatures (without plugging) in the first 400 feet of the great bore, designated Bore I, with the temperatures observed at the same depths during the sinking of another bore, designated Bore II, near it; the observations in this latter being always taken at the bottom. The following were the results:

Depth in feet.	Temperature.	
	Bore I.	Bore II.
100	11·0	9·0
200	11·6	10·4
300	12·3	11·5
400	13·6	12·5

The temperature at the depth of one hundred feet in the great bore thus appears to have been raised about 2° R. by convection.

The following is a table of the successful observations, corrected for pressure:

Depth in Rhenish feet.	Temperature Reaumur.
700	17·275
900	18·780
1,100	21·147
1,300	21·510
1,500	23·277
1,700	24·741
1,900	26·504
2,100	28·668
3,390	37·238

Assuming, with Herr Dunker, the mean temperature of the surface to be 7·18, which is the mean annual temperature of the air at Berlin, we have the following increments of temperature with depth:

Depth in Rhenish feet.	Increment of depth.	Increment of temperature.	Increase per 100 feet deg. Reaumur.	Increase per 100 feet deg. Fahr.
0 to 700	700	10·095	1·442	3·24
700 ~~800~~ to 900	200	1·505	·752	1·69
900 ~~700~~ to 1,100	200	2·367	1·184	2·66
1,100 to 1,300	200	0·363	·182	·41
1,300 to 1,500	200	1·767	·884	1·99
1,500 to 1,700	200	1·464	·732	1·65
1,700 to 1,900	200	1·763	·882	1·98
1,900 to 2,100	200	2·164	1·082	2·43
2,100 to 3,390	1,290	8·570	·664	1·49
0 to 3,390	3,390	30·058	·887	2·00

The mean rate of increase found by comparing the temperatures at the surface and 3,390 feet is exactly 1° Fahr. for 50 Rhenish or 51·5 English feet.

The numbers in the last two columns exhibit upon the whole a diminution with increase of depth; in other words, the temperature increases less rapidly as we go deeper down. As regards the first 700 feet, which exhibit a decidedly more rapid rate than the rest, it must be remembered that nearly half of this distance was in a different material from the rest of the bore, being in gypsum with some anhydrite, while all the rest was in rock salt. Prof. Herschel has found, in recent experiments not yet published, that the conductivity of rock salt is exceedingly high; and theory shows that the rates of increase, in superimposed strata, should be inversely as their conductivities. We may, therefore, fairly attribute the rapid increase in the first 700 feet to the relatively small conductivity of the portion (283 feet) which is not rock salt. The slow rate of increase observed in the long interval between the depths of 2,100 and 3,390 feet is not so easily accounted for; we can only conjecture that this and the other inequalities which the above table presents, for depths exceeding 700 feet, are due to fissures and other inequalities in the rock which have not been put in evidence.

With the view of summing up his results in small compass, Herr Dunker has assumed the empirical formula:

$$t = 7{\cdot}18 + ax + bx^2,$$

t denoting the temperature (Réaumur) at the depth x (Rhenish feet); and has computed the most probable values of a and b, by the method of least squares. He finds

$$a = {\cdot}0129857 \qquad b = -{\cdot}000000125791,$$

the negative sign of b indicating that the increase of temperature becomes slower as the depth increases.

A paper by Prof. Mohr, of Bonn, as represented by an abstract published in *Nature* (vol. xii, p. 545), has attracted attention from the boldness of its reasoning in reference to the Sperenberg observations. Prof. Mohr, however, does not quote the observations themselves, but only the temperatures calculated by the above formula, which he designates, in his original paper (*Neues Jahrbuch für Mineralogie*, etc., 1875, Heft 4), "the results deduced from the observations by the method of least squares." In the abstract in *Nature* they are simply termed "the results of the thermometric investigation of the Sperenberg boring," a designation which is still more misleading. Attention is called to the circumstance that the successive increments of temperature for successive equal increments of depth, form an exact arithmetical progression, as if this were a remarkable fact of observation, whereas it is merely the result of the particular mode of reduction which was adopted, being a mathematical consequence of the assumed formula $t = 7{\cdot}18 + ax + bx^2$. The method of least squares is not responsible for this formula, but merely serves, after this formula has been assumed for convenience, to give the best values of a and b.

Herr Dunker, in his own paper, lays no stress upon the formula, and gives a caution against extending it to depths much greater than those to which the observations extend. Writing to Prof. Everet under date April, 1876, he requests that in the summary of his results to be given in the present Report, the formula should either be suppressed or accompanied by the statement that its author reserves a different deduction.

The following are the differences between the temperatures computed by the formula and the observed temperatures:

Depth.	Difference (computed *minus* observed).
700	−1·621
900	−0·931
1,100	−1·204
1,300	+0·427
1,500	+0·553
1,700	+0·882
1,900	+0·811
2,100	+0·238
3,390	+0·482

The necessity of adopting some means to prevent the circulation of water in bores, has for some time been forcing itself upon the attention of your committee. Many of the observations taken by their observers have contained such palpable evidence of convection as to render them manifestly useless for the purpose intended; and in the light of the Sperenberg experiment it is difficult to place much reliance on any observations taken in deep bores without plugging. The selection of a suitable form of plug is now occupying the careful attention of your committee.

Herr Dunker's paper gives a very full account of the different kinds of plug employed at Sperenberg.

For stopping the mouth of the advance-bore the plug had a tapering shape, and was of hard wood, strengthened by two iron rings, one at each end. and covered with a layer of tow five lines thick, outside of which was thick and strong linen, nailed above and below to the wood, through a leather strap. It was lowered into its place by means of the iron rods used for boring; and, when in position, was pressed home by a portion of the weight of the rods. The plug carried the thermometer suspended from it. Its extraction was commenced by means of a screw on the beam of the boring machine, in order to avoid a sudden jerk, which might have broken the thermometer. The force which was found necessary for thus starting the plug, as well as the impression observed upon it when withdrawn, showed that it had fitted tight. To insure a good fit, the top of the advance-bore had been brought to a suitable shape, and its inequalities removed, by means of a revolving cutting-tool. Herr Dunker remarks that this plan is adapted to a soft material like rock-salt, but that in ordinary hard rock it would be better to make the bottom of the main bore flat, and to close the advance-bore by an elastic disc pressed over it. The method of observation by advance-bores can only be employed during the sinking of the bore, a time when it is difficult to avoid error arising from the heat generated in boring. The expense of making an advance-bore at each depth at which an observation is required is also an objection to its use.

Another kind of plug devised by Herr Dunker, and largely used in the observations, consisted of a bag of very stout india-rubber (nine millimeters thick) filled with water, and capable of being pressed between two wooden discs, one above and the other below it, so as to make it bulge out in the middle and fit tightly against the sides of the bore. On the suggestion of bore-inspector Zobel, the pressure was applied and removed by means of screwing. Two steel springs fastened to the upper disc, and appearing, in Herr Dunker's diagram, very like the two halves of a circular hoop distorted into an oval by pressing against its walls, prevented the upper disc from turning, but offered little resistance to its rising or falling. The lower disc, on the contrary, was permitted to turn. Both discs were carried by the iron boring-rods. Rotation of these in one direction screwed the discs nearer together, and rotation in the other direction brought them farther apart. The india-rubber bag could thus be made to swell out and plug the bore when it was at the desired depth, and could be reduced to its original size for raising or lowering. In order to prevent the boring-rods from becoming unscrewed one from another, when rotated backwards, it was necessary to fasten them together by clamps, a rather tedious operation in working at great depths.

In taking observations at other points than the bottom, two of these plugs were employed, one above the other below the thermometer.

In some of the experiments, the apparatus was modified by using linen bags filled with wet clay, instead of india-rubber bags filled with water; and, instead of screwing, direct pressure was employed, the lower disc being supported by rods extending to the bottom of the bore, while the upper disc could be made to bear the whole or a portion of the weight of the rods above it. Some successful observations were obtained with both kinds of bag; but the water-bags were preferred, as returning more easily to their original size when the pressure was removed, and consequently being less liable to injury in extraction. In some observations since taken in another place (Sudenberg), Herr Dunker states (in the private letter above referred to) that india-rubber bags, filled with water, and pressed, not by screwing, but by the weight of the rods, were employed with much satisfaction.

All the methods of plugging employed by Herr Dunker involved the use of the iron rods belonging to the boring apparatus, and therefore would be inapplicable (except at great expense) after the operation of boring is finished and the apparatus removed.

It seems desirable to contrive, if possible, some plug that can be let down and raised by a wire. In the first report of your Committee, it was suggested that two bags of sand, one above and the other below the thermometer, should be used for this purpose. Bags of sand, however, would be liable to rub off pieces from the sides of the bore, and thus to become jammed in drawing up. Mr. Lebour has devised a plug which will be of small diameter during the process of lowering and raising, but can be rendered large and made to fit the bore, when at the proper depth, by letting down upon it a sliding weight suspended by a second wire. Sir W. Thomson suggests that a series of india-rubber disks, at a considerable distance apart, will probably be found effectual.

Mr. Boot has continued his observations in the bore which he is making at Swinderby, near Scarle (Lincoln). It has now been carried to the depth of 2,000 feet, and is in earthy limestone or calcareous shale, of Carboniferous age. Its diameter in the lower part is only 3¼ inches. In April last the temperature, 78° F., was observed at 1,950 feet; and more recently 79° F. was observed at 2,000 feet; the water, in each case, having been undisturbed for a month. Supposing these results not to be vitiated by convection, and assuming the mean temperature at the surface to be 50°, we have an increase of 29° in 2,000 feet, which is at the rate of 1° in 69 feet.

Mr. Symons has taken a series of observations at the depth of 1,000 feet in the Kentish Town well, with the view of determining whether the temperature changes. The instrument employed is a very large and delicate Phillips' maximum thermometer. The following is a list of the observations :—

Date of lowering.	Depth indicated. Feet.	Thermometer set at.	Date of raising.	Depth indicated. Feet.	Temperature. Fahr.
1874	1000	64·50	May 8	1007	66·82
" May 8	1000	63·80	July 2	1009	(reading lost.)
" July 2	1000	63·20	July 28	1005	67·40
" July 28	1000	65·10	Sept. 8	1004	67·51
" Sept. 8	1000	65·80	Sept. 29	1004	67·43
" Sept. 29	1000	65·81	Oct. 30	1006	67·68
" Oct. 30	1000	63·40	Dec. 3	1006	67·52
" Dec. 3	1000	63·80	Jan. 7	1009	67·63
1875 Jan. 7	1000	63·75	Feb. 1	1006	67·56
" Feb. 1	1000	63·90	March 3	1005	67·58
" March 3	1000	63·90	May 3	1006	67·62
" May 3	1000	63·95	June 1	1005	67·49
" June 1	1000	63·00	July 7	1005	67·53
" July 7	1000	63·87	Aug. 3	1004	67·58
" Aug. 3	1000	63·87	Sept. 10	1004	67·68
" Sept. 10	1000	64·00	Oct. 2	1003	67·58
" Oct. 2	1000	63·90	Oct. 19	1004	67·62
" Oct. 19	1000	63·80	Nov. 1	1005	67·62
" Nov. 1	1000	63·70	Dec. 1	Wire broke.	

The "depth indicated" is shown by a measuring wheel or pulley, over which the wire runs by which the thermometer is raised and lowered, as described, with a diagram, in the Report for 1869. The above table shows that there is always some stretching, real or apparent, in the interval between lowering the thermometer and raising it again. Recent observations by means of a fixed mark on the wire, have shown that the change is not, in the main, a permanent elongation, but an alternation of length. It is probably due in part to the greater tension which the wire is under in raising than in lowering, a circumstance which will cause a temporary difference of length variable with the rapidity of winding up; also in part to the circumstance that the wire is warmer when it has just left the water than when it is about to be let down. Some portion of the irregularity observed may be due to variations of temperature in that part of the well (210 feet) which contains air. The observations, taken as a whole, show that any variations of temperature which occur in this well at the depth of 1,000 feet, are so small as to be comparable with the almost inevitable errors of observation. The observations will be continued at intervals of six months, with additional precautions, and with an excessively slow (specially constructed) non-registering thermometer, in addition to the maximum thermometer hitherto employed.

Through the kindness of the eminent geologist, M. Delesse, of the Ecole Normale at Paris, observations have been obtained from the coal mines of Anzin, in the north of France. They were taken under the direction of M. Marsilly, chief engineer of these mines. Maximum thermometers of the protected Negretti pattern, were inserted in holes bored horizontally to the depth of ·6 or ·7 of a meter in the sides of shafts which were in process of sinking, and in which there was but little circulation of air. A quarter of an hour was allowed to elapse in each case, after the boring of the hole, before the thermometer was inserted, and the hole plugged. Four different shafts were tried. Those designated as Nos. I, II, III, were in the mine Chabaud La Tour; and No. IV was in the mine Renard.

In Shaft I, observations were taken at eight different depths, commencing with the temperature 56½° F. at the depth of 38·5 meters, and ending with 67¾° F. at 200·5 meters.

In Shaft II there were observations at four depths, commencing with 55° at 87·8 m., and ending with 63½° at 185 m.

In Shaft III there were observations at three depths, commencing with 56° at 87·8 m., and ending with 62½° at 144 m.

These three shafts, all belonging to the same mine, were very wet, and the temperature of the air in them was 11° or 12° C. (52° or 54° F.).

In Shaft IV, which was very dry and had an air temperature of about 15° C. (59° F.), observations were taken at six depths, commencing with 70¾° F. at 21·2 m., and ending with 84° F. at 134·8 m.

The mean rates of increase deduced from these observations are:—

In Shaft	I,	1° F. in	14·4 m.,	or in	47·2 feet.
"	II,	"	11·5 m.,	"	37·7 "
"	III,	"	8·65 m.,	"	28·4 "
"	IV,	"	8·57 m.,	"	28·1 "

The observer mentions that in Shaft II there was at the depth of 90 m. a seam of coal, in which heat was generated by oxidation; but no such remark is made with respect to any of the other shafts, although it is obvious that some disturbing cause has rendered the temperatures in shaft IV abnormally high. Possibly the heat generated in boring the holes for the thermometers in this shaft (which was dry) has vitiated the observations, the instruments employed being maximum thermometers. Two of the slow non-registering thermometers mentioned in last year's report have been sent to M. Delesse, to be used for verification.

The slow-action thermometers are constructed on the following plan: The bulb is cylindrical and very strong, and is surrounded by stearine or tallow, which fills up the space between it and a strong glass shield in which the thermometer is inclosed. The shield is not hermetically sealed (not being intended for protection against pressure), but is stopped at the bottom with a cork, so that the thermometer can be taken out and put in again if desired. Stearine and tallow were selected, after trials of several substances, including paraffin-wax, bees' wax, glue, plaster of Paris, pounded glass and cotton wool. The thermometers are inclosed in copper cases lined with india-rubber. When placed, without these cases, in water differing 10° from their own temperature, they take nearly half a minute to alter by one-tenth of a degree.

In concluding this report, your committee desire to express their regret at the losses which they have sustained by the deaths of Professor Phillips, Sir Charles Lyell, and Col. Strange, of whose valuable services they have been deprived within the last three years.

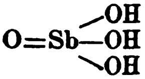
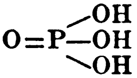
SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On Iodine Trichloride.*—CHRISTOMANOS has described, as an excellent lecture experiment, the preparation of pure iodine trichloride by the action of dry chlorine upon dry hydrogen iodide, the latter gas being conducted into the former in excess. The reaction takes place in two stages: $HI+Cl_2=HCl+ICl$ and $ICl+Cl_2=ICl_3$. At the first contact of the two gases, a transient white dense cloud of hydrogen chloride appears in which float innumerable minute gold-yellow flakes of the trichloride. On increasing the flow of gas, reddish-violet fumes appear and the gas frequently ignites, forming an experiment of great splendor. The walls of the vessel are covered with thick, bright lemon-yellow crystals, which are converted into the monochloride by an excess

of hydrogen iodide, but may be preserved in an atmosphere of chlorine. Iodine trichloride fuses at 32° C., is volatilized at 47·5° (though it gives off vapor even at −12°) and is dissociated at 72° into monochloride and chlorine. It is soluble in cold water without decomposition.—*Ber. Berl. Chem. Ges.*, x, 434, March, 1877.
G. F. B.

2. *On the Atomic Weight of Selenium.*—Petterson and Ehman have redetermined the atomic weight of selenium by several methods, using for analysis calcium selenate, ammonio-aluminum selenate (an alum) magnesium and silver selenites and silver selenate. The numbers obtained not being sufficiently accordant they tried reducing selenous oxide by means of sulphuric acid and determining the selenium precipitated. In five experiments they deduced the atomic weight of selenium as 79·10, 79·06, 79·08, 79·06, 79·08, the mean of which is 79·08, which may be accepted as the true atomic weight of this metalloid.—*Bull. Soc. Chem.*, II, xxvii, March, 1877.
G. F. B.

3. *On Trihydroxylantimonic acid and Antimonyl chloride.*—Analogy points out the existence of an antimonic acid  $O{=}Sb\begin{cases}OH\\OH\\OH\end{cases}$ and an antimonyl chloride $SbOCl_3$, corresponding respectively to  $O{=}P\begin{cases}OH\\OH\\OH\end{cases}$ and to $POCl_3$. Daubrawa has studied the question of the antimonic acids anew, using Berzelius's method for preparing them, i. e., by dropping antimonic chloride into water. The results of analysis showed that the air-dried precipitate was $H_8Sb_2O_9$; dried over sulphuric acid it was H_3SbO_4; at 100° C., it became $H_4Sb_2O_7$; at 200°, $HSbO_3$; at 275°, Sb_2O_5; and above 300°, Sb_2O_4. For the preparation of the oxychloride, one part by weight of water was dropped into sixteen parts by weight of antimonic chloride. A yellowish-white distinctly crystalline mass resulted, which was deliquescent in the air, and which fused, boiled and sublimed in a closed tube, dissociating into SbOCl and Cl_2 at higher temperatures. The analysis, which was difficult, gave the formula $SbOCl_3$.—*Liebig's Ann.*, clxxxvi, 110, March, 1877.
G. F. B.

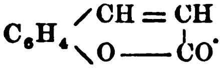
4. *On the Constitution of Cyanamide.*—Of the two rational formulas assigned to cyanamide, $N{\equiv}C{-}NH_2$ and $C\begin{cases}NH\\NH\end{cases}$, the existence of di-silver-cyanamide would seem to fix the latter as the more probable constitution. Fileti and Schiff have proved, however, that this imide formula is actually not the true one. By acting on di-silver-cyanamide with ethyl iodide, di-ethylcyanamide was obtained, identical in properties and in decomposition products with the di-ethylcyanamide obtained by Cloëz, Cannizzaro and Cahours from cyanogen chloride and diethylamine. As in this latter body the two ethyls are united to the same nitrogen atom—since it came from diethylamine $NH\begin{cases}C_2H_5\\C_2H_5\end{cases}$—it

follows that they are in the former; and hence that the rational formula of cyanamide itself is $N{\equiv}C{-}NH_2$.—*Ber. Berl. Chem. Ges.*, x, 425, March, 1877. G. F. B.

5. *On Potassium triiodide.*—Johnson has succeeded in obtaining potassium triiodide by evaporating a saturated aqueous or alcoholic solution of iodine in potassium iodide, over sulphuric acid. At first dark colored cubes of the iodide colored by iodine appeared; but after some days, lustrous dark blue prismatic crystals were deposited, sometimes two inches long, which afforded the composition of the tri-iodide on analysis. This substance is very deliquescent, becoming a brown liquid on exposure to the air. Its specific gravity at 15° was 3·498. From the fact that its atomic volume is 120·2, by experiment, and 122·2 by calculation from the sum of the atomic volumes $K+I_3$, but only 105·64 from $KI+I_2$, the author infers that it is an atomic and not a molecular compound.—*J. Ch. Soc.*, xxxi, 249, March, 1877. G. F. B.

6. *On Ethyl-mercaptan and its Derivatives.*—In the course of an extended investigation into ethyl-mercaptan and the corresponding mercaptides, Claesson has made the curious observation that the group $-\cdot-S.C_2H_5$ of mercaptan is readily exchanged for the haloid constituents of the fatty series, the substitution taking place the more readily the less condensed the carbon nucleus of the compound. Thus by acting on carbon tetrachloride with mercaptan in presence of sodium ethylate, sodium chloride separates, the liquid boils from the heat evolved, and a light yellow oil of 1·01 specific gravity is obtained, which the author calls carbon-tetra-mercaptide, and which has the formula $C(S.C_2H_5)_4$. He has prepared also dicarbonhexamercaptide $C_2(S.C_2H_5)_6$ and dicarbontetramercaptide $C_2(S.C_2H_5)_4$. The author has prepared also ethyl-tetrasulphide $(C_2H_5)_2S_4$ and has studied its properties and reactions.—*J. pr. Ch.*, II, xv, 193, March, 1877. G. F. B.

7. *On the Synthesis of Coumarin.*—Tiemann and Herzfeld have effected a new synthesis of coumarin. They were led to the method by observing that acetylparacumaric acid was obtained when paroxybenzaldehyde was heated with acetic oxide and sodium acetate, and that benzaldehyde similarly treated yielded cinnamic acid; from which they inferred that salicylaldehyde (orthoxybenzaldehyde) would yield an acetylorthocumaric acid and so coumarin. The reaction readily took place, and the expected acid was produced, and from it also ortho-cumaric and hydro-orthocumaric (melilotic) acid. By simple heating, acetylorthocumaric acid was decomposed into acetic oxide and acid and coumarin which was obtained pure by recrystallization from ether. The authors consider it a lactide-like anhydride with the formula

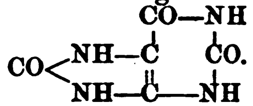


$$C_6H_4\Big\langle\begin{matrix}CH=CH\\ \quad\;\;|\\ O\;\text{——}\;CO\end{matrix}$$

.—*Ber. Berl. Chem. Ges.*, x, 283, Feb. 1877. G. F. B.

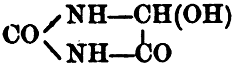
8. *On the Decomposition of Glyoxalyl-urea.*—To test the question whether the substance obtained by protracted boiling of a

solution of uroxanic acid was really glyoxalylurea, as assumed, **Medicus** acted upon it with potassium hydrate, which would split it into urea and glyoxalic acid, and then would decompose the latter into oxalic and acetic acids. The products were examined and proved to be those mentioned. Hence the author regards as proved his formula for uric acid which is



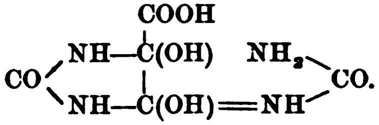
$$CO<\begin{array}{l} \qquad\quad CO-NH \\ NH-\overset{|}{C}\quad \overset{|}{C}O. \\ NH-\overset{\|}{C}-\overset{|}{N}H \end{array}$$

Glyoxalylurea is



$$CO\begin{array}{l} \diagup NH-CH(OH) \\ \diagdown NH-\overset{|}{C}O \end{array}$$

and uroxanic acid is



$$\begin{array}{l} \qquad\quad COOH \\ CO\begin{array}{l} \diagup NH-\overset{|}{C}(OH)\quad NH_2\diagdown \\ \diagdown NH-\overset{|}{C}(OH)=NH\diagup \end{array}CO. \end{array}$$

—*Ber. Berl. Chem. Ges.*, x, 544, April, 1877. G. F. B.

9. *On two new Alkaloids, Strophantine and Ineine.*—**Hardy** and **Gallois** have examined the poison variously known as inaye, onaye, gombi, etc., extracted in Africa from the seeds of *Strophantus hispidus*, a climbing plant belonging to the Apocyneae. Fraser examined this substance and obtained from it an active extract, to the alkaloid in which he gave the name Strophantine. The authors have succeeded in preparing this body crystallized and have shown that it arrests the action of the heart, the ventricles being in systole. From the tufts about the seeds, they have also obtained a second alkaloid which they call ineine.—*Bull. Soc. Ch.*, II, xxvii, 247, March, 1877. G. F. B.

10. *Occurrence of Copper normally in the Blood of Wild Animals.*—**Cloëz**, having to incinerate the blood of a roebuck, killed in the woods, and to analyze the ash, was surprised to detect in it an appreciable quantity of copper. Fearing that it might have entered by accident during his operations, he repeated the analysis on the blood of another buck, taking special precautions. The result was the same, the 530 grams of blood affording three milligrams of copper oxide. It must have existed either in the plants eaten as food by the animal or in the water which he drank.—*Bull. Soc. Ch.*, II, xxvii, 196, March, 1877. G. F. B.

11. *Is Glass impervious to Gases?*—Professor G. **Quincke** has tried to force hydrogen and carbonic acid, by pressures of from 40 to 120 atmospheres, through a glass wall 1·5 mm. in thickness, and to determine by the loss of weight, the quantity of gas that had passed through during seventeen years.

One leg of a V-shaped glass tube was a capillary tube of 200 mms. in length, closed above; the other was a tube contracted in the middle and open above, 150 mms. long, 8 mms. in diameter and 1·5 mms. thick. Into the open leg a drop of quicksilver was put; upon this dilute sulphuric acid was poured; into the upper part some sheet zinc was pushed, which was kept from contact with the acid by the contraction of the tube; and then the open end was carefully closed by fusion at a glass-blower's lamp. Four tubes thus prepared underwent a double weighing; and then, by inclining the tubes, the sulphuric acid was brought into contact with the zinc. The pressure of the hydrogen was shown by the diminution of volume of the air in the capillary tube, which served for a manometer. Its amount on the first day, in the different tubes, was from 1¼ to 10 atmospheres, rose in five months up to 27–54 atmosphere and in 17 years up to 25–126 atmospheres. During this time the tubes were frequently doubly weighed on an excellent balance; and exactly the same weight, within from 0·1 to 0·3 of a milligram, was always found.

Another similar tube, with carbonate of lime and concentrated sulphuric acid, in which the pressure of the carbonic acid gas amounted on the first day to 21 atmospheres, after five months to 34 atmospheres, and after 17 years to 44, showed likewise always the same weight of 14·6361 grams.

Thus according to these experiments, a pressure of from 40 to 100 atmospheres cannot, during a space of seventeen years, force through 1·5 mm. thickness of glass a perceptible quantity of hydrogen or carbonic acid.

While at the commencement the concentrated sulphuric acid wetted the glass sides of the tube, and showed a sharp marginal angle (apparently 0°), gradually in the course of years the angle has become obtuse, and the acid flows in the tube with condensed carbonic acid like quicksilver in a glass tube filled with air.

In the atmosphere of hydrogen the angle at the margin of the dilute sulphuric acid, which at first likewise wetted the sides, has also increased to about 60°.

The glass thus appears to have gradually in the course of years, under the influence of the great pressure, become coated with a thin layer of carbonic acid or hydrogen respectively, which exerts a different attraction from that which glass exerts upon the liquid particles at the margin of the surface. A similar film of gas must have been deposited on the surface of the zinc and obstructed the further chemical action of the acid.—*Pogg. Ann.*, clx, 118; *Phil. Mag.*, iii, 314. E. C. P.

12. *Polarization of the Rainbow.*—M. J. Dechant explains the observations of Schiel and Tyndall that the light of the rainbow could in all cases be extinguished by a Nicols' prism, by Fresnel's formula for the reflection of light. The light falls on the posterior wall of the drop at an angle of 40°, while the angle of total polarization is about 37°. The ratio of the two polarized beams for the red rays is consequently about 24·5 and for the violet rays 34·9. Or, the rainbow is diminished in brightness 25 to 35 fold when the Nicol is rotated 90°. If the index of refraction of the liquid was $\sqrt{2}=1{\cdot}414$ the polarization would be complete. Calculation shows that for oil of cassia the ratio of the red rays is 6·3 and of the violet 2·8. Forming a rainbow by scattering this liquid in sunlight by an atomizer the light cannot be extinguished by a Nicol prism in any position.—*Pogg. Ann.*, clx, 123. E. C. P.

13. *The Radiometer.*—Two views have been offered as to the mode of action of the gas in the radiometer. One attributes the motion to reaction of gas particles getting heated on the vanes, then dancing off; the other to air currents which are directed toward the plate in consequence of heated air rising from it. M. Neesen has endeavored (Pogg. Ann.) to decide between these views. If the second view is correct, he argued, the wall of the vessel, by becoming also heated, must also acquire influence through rise of heated air from it as from the vanes. If the rotation be merely a phenomenon of reaction there is no reason to suppose such an influence of the fixed wall. Now by giving the radiometer an eccentric position within the glass vessel such an influence of the walls should be readily recognized. He describes a number of experiments made in this way, and which he regards as supporting the second view.

In an article contributed to Poggendorff's Annalen, M. Zöllner is led to take the following positions in reference to the radiometer. The explanation of radiometric motions based on the principles of the mechanical theory of gases, make suppositions about the relation of the mean lengths of path of the gas molecules to the dimensions of the vessel which are not realized in fact. This explanation further leaves out of consideration, without sufficient ground, the simultaneous existence of mercury vapors whose molecules have a more then seven times greater mass and a much smaller mean length of path than the molecules of the gases acting according to the mechanical theory of gases. Hence we are not warranted in regarding the radiometric motion discovered by Crookes as an empirical confirmation of the mechanical theory of gases.—*Nature*, xv, 521. E. C. P.

14. *Fluorescence.*—M. E. LOMMEL discusses the intensity of the light of fluorescence assuming that the quantity of the light which an element of volume of the fluorescent substance can emit is proportional to the quantity of exciting light which is absorbed. He concludes:

(1.) That with an increasing concentration, the intensity of the fluorescent light at first increases up to a certain minimum, and then decreases.

(2.) That the ratio of the light emitted by a superficial layer of given thickness, to the total fluorescent light, increases with the intensity of the absorption, and is as much more feeble as we observe it at a greater distance.

(3.) That the mixture of colors which constitutes fluorescent light changes with the coefficient of absorption of the exciting light, in such a way that the ratio of the intensities approaches more and more that which characterizes the type of the fluorescent spectrum, to the extent that the exciting rays are capable of being absorbed.

(4.) That the fluorescent light, observed at a great distance, is formed of a mixture of colors in which the rays very largely absorbed are in less proportion than when the observation is made at a small distance.

(5.) That by observing the fluorescence by transparency as Lubarsch has done, the proportion of the rays most absorbed is strongly diminished.

(6.) That it is, on the contrary, as great as possible when, the observation being effected on the side of the incident rays, the angle of incidence is very great.

All these conclusions follow naturally from the first proposition and seem to involve only very natural hypotheses.

This theory demands nothing but that the law of Stokes shall be in general correct. It explains, on the contrary, very well the disagreement of the experiments of Lommel, made under conditions theoretically more favorable than those of his opponents.—*Pogg. Ann.*, clx, 75, *Journ. de Phys.*, vi, 126. E. C. P.

15. *Electricity and the Electric Telegraph;* by GEO. B. PRESCOTT. 978 pp. 8vo, with 564 illustrations. New York. 1877. (D. Appleton & Company.)—This volume, by Mr. Prescott, is a most important contribution to scientific literature, honorable alike to the learning and industry of the author. It is a comprehensive review of the application of electrical principles to telegraphy. It discusses with sufficient thoroughness the laws of electrical resistance and measurement; the determination of voltaic constants; the laws of electro-magnetism; of the measurement of electro-motive force; of galvanic polarization and the application of these and other principles to telegraphic circuits and land lines; the phenomena of charge and discharge on land lines and underground lines; submarine cables; electrostatic induction on telegraph lines; the phenomena of charge in submarine cables; coefficient of charge in submarine and land lines; duration of the variable state when the extremity of the line is to earth, and when it is insulated; the time required to produce a signal; the earth a reservoir of electricity, and its electrical resistance. These topics fill nearly half (415 pages) of the volume; the remainder is occupied with a historical notice of experimental telegraphs of the American and European Morse system, and a full notice of all other systems and instruments, illustrated by very beautiful, original wood-cuts. The discoveries and improvements of late years, especially the duplex and quadruplex modes of transmission, and the improved type printing apparatus, which, as the author says, have in America almost revolutionized the telegraph service, are now for the first time illustrated with a completness worthy of the importance of the subject. The harmonic telegraphs or telephones are also described and illustrated. Mr. Prescott's book is prepared with great care, giving to each investigator and inventor just consideration: and while it is full in its technical detail it is also thorough in its scientific accuracy, qualities rarely combined, and worthy of the electrician of one of the most widely extended telegraphic organizations in existence. B. S.

II. GEOLOGY AND NATURAL HISTORY.

1. *Annual Report on the Geographical Surveys west of the 100th Meridian*, by G. M. WHEELER, 1st Lieut. Eng. U. S. A. 356 pp. 8vo, with many maps and plates. Washington, 1876. —Lieutenant Wheeler's Report, extending to 79 pages, treats of the general results of the expedition. It is followed by appendixes, containing geographical, geological and other information, by Lieut. W. L. MARSHALL, Lieut. E. BERGLAND, Lieut. W. L. CARPENTER, Lieut. R. BIRNIE, Jr., Lieut. C. C. MORRISON, and Lieut. C. W. WHIPPLE; on meteorology and hypsometry by Lieut. W. L. MARSHALL; on the geology and mineralogy of Southeastern California—the alkaline lakes, thermal springs and brackish waters of Southern California—the physical and agricultural features and ethnology of Southern California — the meteorology of the Mohave Desert and the geographical distribution of its vegetation, by Dr. O. LOEW; on the geology of a portion of Southern California by Prof. J. MARCOU; on the geology of the mountain range from La Veta Pass to the head of the Pecos, by A. R. CONKLING; economic botany and agriculture of Southern California, by Dr. J. T. ROTHROCK; on the ornithology and the mammals of portions of California, by H. W. HENSHAW; on Orthoptera, by S. H. SCUDDER; on Coleoptera, by Dr. J. L. LECONTE; on the Alpine insect fauna, by Lieut. W. L. CARPENTER; on eleven idioms spoken in Southern California, Nevada and on the Colorado River, by A. S. GATSCHET.

In the paper by Prof. J. Marcou, the Tertiary beds of Chico Creek, California, are referred to the Eocene Tertiary, instead of Upper Cretaceous, notwithstanding the presence of a few Cretaceous species, as *Ammonites Chicoensis*, and *Baculites Chicoensis*, the species, with these exceptions, having prominently a Tertiary character.

2. *Geological and Geographical Survey of the Territories*, F. V. HAYDEN, U. S. Geologist in charge.—Bulletin No. 2 of vol. III, recently issued contains a paper on Western Diptera, comprising descriptions and new genera and species, by C. R. OSTEN-SACKEN, occupying 165 pages; a report on Insects collected by P. R. Uhler in 1875, and of Hemiptera collected by A. S. Packard, Jr., by P. R. UHLER, with two plates, extending to 120 pages; and descriptions of the Araneæ collected in 1875, by A. S. Packard, Jr., by T. THORELL, over 50 pages. The memoir by P. R. Uhler contains monographs of the families Cydnidæ and Saldæ.

3. *Contributions from the Laboratory of the University of Missouri;* Report by the Curators of the University of Missouri, to the Governor of the State. Includes a paper by Prof. P. Schweitzer on the various methods of separating and determining Barium, Strontium and Calcium; a paper by C. P. Williams on the composition of Missouri leads (in which the lead constitutes 99·91 to 99·993 per cent, and the silver 0·00029 to 0·00615 per

cent); and analyses of Copper ores, Smithsonite from Dade County, etc.

4. *Organogeny of the Female Flower of Gnetum Gnemon. Della Organogenia dei fiori feminei del Gnetum Gnemon* L., *nota di* O. BECCARI. Extr. from *Nuovo Giornale Botanico Italiano*, vol. ix, No. 1. Jan. 1877. With a plate.—Beccari's observations and notes were made at Ternate, in the Moluccas. He was not aware that anything on the subject had then been published in Europe; but in his paper he refers to Griffith as having first asserted that the whole floral apparatus in question belongs to the ovule. Beccari describes the proper female flowers, viz: those of the fertile ament, and distinguishes from them the abortive female flowers which accompany the male ament. The latter have only two envelopes and no embryo-sac; the former have three, and the embryo-sac appears at the time of pollination. The ovule or female flower—whichever it be called—is developed in the axil of an ament-scale, the nature of which is unquestioned; it is sessile, and surrounded by some multicellular "paraphyses." Its body or central part is an ovular nucleus. The question turns upon the nature of the coats. Now these form in succession from without inwards; i. e., the external one is the oldest, and at an early stage is 2-toothed or 2-lobed at apex, as if formed of two confluent parts. Within this appears a second, as a ring or cupule around the base of the nucleus, which in due time it encloses; it shows no indication of a bipartite division or lobing. Soon after this becomes manifest, the third coat originates similarly within the second, advances beyond it and beyond the nucleus, being extended into a styliform tube with a 2-parted apex. This internal and flask-shaped coat is found in the sterile female flowers of the male ament, but is less prolonged; the external coat equally exists; but the intermediate coat is wanting.

It is taken for granted, on whatever view of the homology, that we have to do with a secondary axis, in the axil of a bract, and that the nucleus is the termination of this axis. According to Griffith the enclosing sacs are coats to the ovule, of which the central body is the nucleus; consequently, this ovule has the anomaly of three integuments. According to Beccari, the nucleus is the whole ovule, viz., an ovule without coats in the manner of that of *Loranthaceæ* and *Santalaceæ*, and the coats are floral organs. A comparison with the quasi-hermaphrodite flowers of *Welwitschia* assures him that the middle and shortest envelope answers to the andrœcium in those flowers, whence it follows that the outer covering is perigonial and homologous with the floral envelope of *Welwitschia*,—only that is tetraphyllous, this is simpler and confluent-diphyllous. It follows also that the innermost sac is carpellary and diphyllous. The gist of the argument in support of this view turns upon these two considerations: 1. *Gnetaceæ* with other Gymnosperms are the lowest type of Phanerogamia; it is most unlikely that such a low type would be provided with such a high type of ovule as one having three coats;

it is more likely that the ovule of *Gnetum* would correspond with the simplified one of *Loranthaceæ*, with which the relationship is not indistinct. 2. The order of evolution of these coverings, i. e., from without inwards or from below upwards, is that of leaves or whorls upon an axis, and of the floral organs in a flower; while ovular coats, as is well known, form in reverse order, the external one latest. The evidence is fairly convincing, and other recent investigations point to the same conclusion.

Some accompanying theoretical deductions drawn by Beccari are not so convincing nor so important. Nor need we share the hesitation with which he uses the name of *Gymnospermæ*. He prefers to continue the term because the ovules, though not destitute of ovary, are destitute of proper ovular coats. But so are not a few angiospermous plants. We should continue it under the original signification, because, admitting the flask-shaped envelop to be homologous with pistil, it is not functionally one; for the pollen reaches and acts directly upon the ovule itself, and not through the intervention of a stigma. Ovules reduced to the nucleus only were not known to Robert Brown, or at least were not considered by him in their present bearing. Being now recognized, the question whether the coat of the seed in *Coniferæ* and *Cycadaceæ* is of carpellary or ovular origin may remain an open one, or may be decided in favor of the former, without essentially derogating from the fitness of the received name for this marked group of orders. Moreover, in flowers so little differentiated as those of *Coniferæ*, the distinction between ovular and carpellary envelopes may be really not cognizable because not yet actual, and so the question may be one of words; while in *Gnetaceæ* an important advance is made, and the ground of a distinction between ovular, carpellary, and perianthial envelopes begins to appear.

If this be so, a vexed question in classification may find a practical settlement. The cultivators of fossil botany, finding that Gymnosperms were far the earliest phænogamous plants, and that no angiospermous Dicotyledons have been detected until long after the appearance of Monocotyledons, almost universally treat the Gymnosperms as a primary division or class of the Vegetable Kingdom. They are seconded by the histologists or organogenists, who naturally make the most of those interesting points of structure which they have brought to view, and which approximate the Gymnosperms to the Vascular Cryptogams. But the question whether Gymnosperms are a part—the earliest and simplest part—of the great class of Dicotyledons, or whether they constitute an independent class or primary group, must be determined by broad and general considerations of the whole structure. Now the transition from *Gnetaceæ* to Angiospermous Dicotyledons is obvious and apparently real. If no transitions are extant between the Gymnosperms and Cryptogams, and if—as is clear—the former are truly Dicotyledonous and exogenous in structure, and have greater affinity with the Angiospermous Dicotyledons than they have with the Monocotyledons, then the taxonomist would appear to have good grounds for concluding that the proper division of the vegetable kingdom is, first into *Phanerogamia* and *Cryptogamia;* then the former into *Monocotyledons* and *Dicotyledons*, then these last into *Gymnosperms* and *Angiosperms.* A. G.

5. *The Paleontological Origin of those trees and shrubs indigenous to the south of France, which are sensitive to Frost in cold winters* (*Sur l' Origine paleontologique, etc.*); by CHARLES MARTINS, 1877, 4to. Extr. from Mém. Acad. Montpellier, tom. ix, pp. 87–122.—Prof. Martins gives a list of 19 of those woody plants which are killed down to the ground by the cold which is occasionally experienced at Montpellier, or on the Mediterranean coast from Peripignan to Mentone, but which spring again from the base and flourish until another exceptional frost occurs. The list ranked in the order of tenderness, begins with the Carob-tree, *Ceratonia siliqua*, and ends with *Vitis vinifera.* With very few exceptions, these plants are solitary representatives in Europe of their genus and tribe; they are represented in a fossil state in the Tertiary formations of S. Europe and also of middle Europe, either by identical species, or by others so similar that they are regarded by paleontologists as equally ancestral. Wherefore, upon a full discussion of the details, it is concluded that these are remains of the Tertiary flora of Europe, which have thus far resisted with success the rigors of a present climate to which they are not completely adapted. A. G.

6. ALEXANDER BRAUN.—We announce with sorrow the death of this excellent botanist, which took place in Berlin, on the 29th of March, after a short illness. Systematic botanists of the first class are everywhere rare, and especially in Germany, where they have gone out of fashion, all attention being turned to histology and the like. In Braun's earlier days there was a goodly array of systematic botanists in Germany: at his decease there are very few of mark, although signs of revival are apparent. Alexander Braun was born at Ratisbon, May 10, 1805, but was brought up at Carlsruhe, where his father became a trusted officer in the post office department. Fifty years ago, there was a knot of closely-allied students at the University of Heidelberg, consisting of Braun, Carl Schimper, Agassiz, and Engelmann. Two of them were transferred to our own soil; the latter is now the sole survivor. Three of them went soon to Munich, where Oken, Schelling, Dollinger, and Martius were teaching; but Braun, Agassiz, and Engelmann met again as fellow-students at Paris in 1832. The first two became allied afterwards by the marriage of Agassiz with Braun's sister. About the time that Dr. Engelmann came to the United States, Braun was made professor of Botany and Zoology in the polytechnic school of Carlsruhe. In 1846 he took the chair of Botany in the University of Freiburg in the Briesgau; was transferred to Giessen in 1850; but in the spring of 1851 was called to Berlin, as the successor to Link and Kunth, taking charge of the Botanic Garden as well as of the professor-

ship. Although he had nearly reached the age of 72, and felt the full weight of his years, yet he was assiduously attending to his official duties when he was suddenly prostrated by acute disease of the chest, terminating fatally. Although learned in almost every department of his science, his *forte*, like that of Agassiz, was morphology, and his systematic work mainly among the higher and some of the lower Cryptogamia, *Marsilia*, *Isoetes*, *Chara*, etc. Although his communications to the scientific journals began as early as the year 1822, when he was only 17 years old, his first contribution to science of much extent, and of high and permanent value, was his memoir on the arrangement of the scales of pine-cones, etc., published in 1830. With this publication began the present knowledge of phyllotaxis. It is well understood that the first steps were taken by his fellow-student, Carl Schimper, and that the early investigations were pursued in common by the two. But Schimper published nothing, or next to nothing, either then or since, although he lived until the year 1867. His name in connexion with the subject is preserved by the favorable mention of his companions and contemporaries; but Braun's treatise was timely and fruitful, and became classical. Braun's ability for the philosophical treatment of vegetable morphology and development was manifested in his next large paper, viz: in his memoir entitled Rejuvenescence in Nature, especially in the life and development of plants. This was first published at Freiburg in 1849–50, and again at Leipsic in 1851, and an English translation of it was published by the Ray Society in 1853. Of a similar character, and marked with equal acuteness, is his essay on The Vegetable Individual in its relation to Species, etc., published in 1853 at Berlin, and which, in a translation by a pupil of mine, was mainly reproduced in this journal (May and Sept., 1855). He reaches the conclusion—which would now be more confidently expressed—"that the individual appears in its full import only in the higher steps of the series of created beings."

In his systematical work, Braun was exceedingly laborious, persevering, and conscientious. When we add that throughout the riper and what should have been the most productive years of his life, he was overtasked with official duties and cares, we shall not wonder that much which he hoped to accomplish is left undone. His work upon *Marsilia*, *Pilularia*, and *Isoetes* may be essentially complete. But his prolonged studies of *Chara*, which began forty years ago, and the completion of which would have crowned his career, have probably not been finished, or brought into such form that the results may be fully secured.

His influence as a teacher is said to have been great; as an investigator he stood in the first rank among the botanists of our time; as a man his simple, earnest, and transparently truthful character won the admiration and love of all who knew him.

A. G.

7. *Notice of Recent Works on Vegetable Paleontology;* by L. LESQUEREUX.—Professor O. HEER has added a fourth volume to his Arctic Flora, a noble supplement to a great and justly celebrated work. The volume contains representatives of the Spitzbergen flora at four epochs of the Carboniferous, the Jurassic, the Cretaceous and the Miocene. It thus affords materials for comparison with those of the same far distant geological times whose floras have become more intimately known from their representatives in the middle part of Europe, and partly, or for the Miocene and the Carboniferous, from those studied from the American continent also.

The first part describes species of the upper Carboniferous of Bell Sound. Even if the stage of the formation, where the plants have been found, is not positively ascertained, the character of these plants point to a more recent deposit than that of Bear Island, described in the second volume of the Arctic Flora. For, out of twenty-six species, it has seven small ferns, *Sphenopteris* and *Adiantites*, a single *Lepidodendron*, one *Stigmaria*, three *Sphenophyllum*, and three *Cordaites*, with a new genus, *Rhynchogonium*, established for beaked fruits clearly related to *Næggerathia* or *Cordaites*, by its linear ribbon-like striated leaves. One species more than any other, shows the relation of this group of plants to the upper Carboniferous; a *Walchia*, a genus mostly Permian. For there is as yet positive evidence of its presence in the Carboniferous by one species only, in the upper part of the formation in Europe, and none in that of this continent. This small group of Carboniferous plants of Spitzbergen differs in its character from that of Bear Island, which, referable to the Subcarboniferous (the Culm or Mountain Limestone,) separated by Heer in two different periods, has *Calamites radiatus* (*Bornia*), species of *Cardiopteris*, one *Paleopteris*, one *Sphenopteris*, the only plant of a type analogous to the species of Spitzbergen, and the balance, large *Lycopodites*, of the genera *Lepidodendron*, *Knorria*, *Cyclostigma*, *Halonia*, etc., all related to types considered in Europe as representatives of the flora of the Culm and in America of the Subcarboniferous. *Cardiopteris* and *Paleopteris* are of a still more ancient type rarely found in the Subcarboniferous of this country. This division is important as recording for the plants of the Coal in the Arctic regions a distribution analogous to that which is now recognized in the temperate zone of both Europe and America.

The Jurassic flora of Cape Boheman in Spitzbergen, thirty-two species, is supplemented in the same volume by that of the Amour and of Eastern Siberia, eighty-three species, whose analogy with the Jurassic flora of England is marked by sixteen species, and by seven with that of Boheman; a relation showing, as in the Carboniferous flora, an analogous distribution of species in the Arctic and the temperate zones during the Jurassic times. In his introduction, Heer rightly remarks on the importance of the characters of those northern Jurassic types, as putting aside the assertion that as long as we knew nothing of the old floras of the Polar regions, we could not really argue upon the analogy of the floras over a whole continent at a given period of time. From the Carboniferous to the Miocene inclusive the same relation is remarked in the plants of the continent of Europe, and so far as the floras are known, in that of America from the 40th to the 80th degrees of latitude. In tracing analogous or identical types from the Carboniferous flora of Portugal, from the Jurassic of England, from the Miocene of Italy, to those of the same formations of Greenland and Spitzbergen, we can derive reliable conclusions in regard to the characters of the vegetation of these epochs over the whole northern hemisphere, if not over the whole world.

Of the descriptions of the species of these Jurassic plants in the fourth volume of the Arctic Flora, of the perfection of the figures with which they are illustrated, it is not possible to speak with too high commendation. The more common types, that of the *Ginkgo*, of the *Baiera*, while especially represented by numerous figures, are restored in their predominant characters. A new genus, *Czkanowskia*, related to *Trichopitys* of Saporta, has two species exposed in their different organs by two full plates of figures. *Baiera longifolia*, *Ginkgo sybirica* are represented with leaves, flowers and fruits, the fructification of the *Ginkgo* being very similar to the small *Cardiocarpus* of the Coal. One of its species, *Podozamites lanceolatus* is, in its leaves, remarkably similar to the one described as *Pterophyllum? Haydenii* in the Cretaceous flora of Nebraska.

A few vegetable remains of the Cretaceous of Cape Staratschin, already mostly known as described in a former volume, constitute the third part, a very short one, of three pages and half a plate of figures.

The fourth part is a supplementary description of seventy-one Miocene species of three different localities of Spitzbergen: Cape Lyell, the Scott Glacier, and Cape Heer. The relation between the plants of these localities is indicated by a comparatively large number of species, thirty-four being common to Cape Lyell and Scott Glacier, and seven found also at Cape Heer, which has only fifteen species for its flora. Considering the whole group altogether we find it related to the Greenland Miocene flora by twenty species, to that of Alaska and Sitka by eleven, five of which are also present in Greenland; to that of Europe by twenty-one, and to that of the Upper Lignitic of the Rocky Mountains, the Carbon and the Green River groups, by seven. This relation is more than sufficiently close to prove contemporaniety of the formation, even with the North American Miocene, though the number of identical species may appear small. It is even more evident than with the European Miocene; for the Tertiary flora of this last continent is now known by more than four thousand species, while, including even the Lower Lignitic Eocene, we know scarcely as many hundred from the North American Tertiary formations. Therefore the conclusions taken in considering the distribution of the Carboniferous and Jurassic floras are valid in the same degree for the Miocene. The essential types of the vegetation of this epoch are the same over the whole northern hemisphere, modified, however, by a difference already remarked in the climatic circumstances of regions under distant latitudes. For the Spitzbergen Miocene flora has no species of Ficus, nor any kind of Laurineæ. It has, however, two Magnolias representing, probably, the highest degree of temperature of the Arctic of that epoch, equivalent to that at the present time of the middle States of North America, South Pennsylvania, and Ohio, for example, while the Tertiary flora of the Western Territories, Colorado, and Wyoming, has from the Eocene to the upper group, the Pliocene of California, representatives of species now inhabiting the shores Gulf of Mexico, and extending even as far south as Cuba and New Mexico.

The description of eight species from Disco, with two plates of illustrations, closes this fourth part of the Arctic Flora. The species are mostly referable to Jurassic types.

The volume under consideration has been prepared from specimens collected by the Swedish Polar expeditions in the years 1872 and 1873. These specimens were examined by Heer and described in 1874; but the publication of the work then ready has been delayed by circumstances independent of the author's control. In the meanwhile, the celebrated Professor has undertaken the preparation of the floras of the different geological formations of Switzerland, beginning with that of the Carboniferous, just published.* The second part, that of the Jurassic, is complete also, and ready to appear. The Carboniferous flora represents the plants of the Anthracite of Vallais, a formation of very limited extent. The general character of these plants is that of the Upper Carboniferous, marked mostly, at least, by a preponderance of ferns: *Sphenopteris*, *Neuropteris*, *Cyatheites*, *Pecopteris*, etc.; the *Calamariæ* and the *Cordaites*, which the author considers as Conifers. A number of species of *Lepidodendron* and *Sigillaria* are still in this group; and as it has also *Sphenopteris latifolia*, *trifoliata*, etc., the large *Alethopteris*, *A. nervosa*, *Serlii*, *muricata*, *Pluckneti*, which in our Coal measures are more abundant in the middle group or above the Millstone grit, the general facies of this Anthracite flora, judging from the American point of view, is rather that of the middle than of the upper Carboniferous. But it has one species of *Walchia* which, together with some ferns, *Pecopteris arborescens*, *Neuropteris Loschii*, etc., are mostly abundant in the upper Coal measures, even passing to the Permian, and therefore the conclusions of the author on the age of the formation have part of the evidence in their favor. A peculiar trait, marking the vegetable remains of the Anthracite of Switzerland, is the presence, upon the surface of the leaflets of ferns especially, of a coating of very hard carbonaceous matter, nearly transformed into graphite, which generally obliterates the nervation, and the deformation of these pinnules which are often drawn and elongated on one side of the pinnæ while they are contracted or shortened and enlarged on the other. The fossil plants of Rhode Island present exactly the same appearance, the dimorphism of the ferns being there still far more distinctly marked than in the species figured by Heer, and the nervation rendered quite as obscure by the superposition of the coating of hard coaly matter, apparently a transformation of the epidermis by heat. I have tried to explain the deformation of the ferns, as a result of a slow movement of upheaval in successive undulations of the strata as it is remarked along the beach of Newport; a movement which, while the plants were still in a soft state, caused an extension or traction to one side, and therefore this peculiar deformation of the leaflets when placed on one side of the line of the force of upheaval. Another remarkable coincidence is, that *Neuropteris alpina* St., a very rare species, found in Europe only in the anthracite of Switzerland, is found also at Newport, and has not been until recently seen anywhere else in the American Coal-measures. The Carboniferous flora of Heer contains descriptions and figures of one hundred species, seventeen of which are considered as new by the author.

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* Flora fossilis Helvetiæ. Erste Lieferung. Die Steinkohlenflora. Zurich. 1876. T. Wurster & Co.

Professor Heer has, it seems, opportunity to study plants of most of the geological formations of Europe, and indeed his profound knowledge of fossil botany seems to render every work related to this science an easy task for him. He has also recently published a pamphlet on some Permian plants of Hungary,* and there describes one species of *Baiera*, one of *Ulmannia*, two *Voltzia*, one *Schizolepis*, with six *Carpolithes;* these all new species. The work exposed in this short review, and which scarcely represents two years of the labors of the celebrated professor, would make an honorable record for a whole scientific life.

Another European paleontologist, Count SAPORTA of Aix, enjoying a degree of celebrity as high and as well merited as that of Professor Heer, and equally versed in the study of the fossil plants of the different formations of Europe, has lately with the assistance of his friend, Dr. Marion, published the Pliocene flora of Maximieux. By the exposition of transitional forms traced to living species of the same country, this flora is like a link between the vegetation of the Miocene and that of the present time, and thus affords evidence on the succession and modification of vegetable types which has not been obtained elsewhere until now. The work† describes thirty-two species splendidly illustrated, most of the figures having in contraposition a representation of the living species to which they are compared as identical or intimately related. The exhibition of this relation gives subjects for consideration as instructive to American as to European botanists, if not more so. We find in it a species of *Torreya*, a genus out of Europe now, but present in California; *Platanus aceroides* var. *cuneifolia* intimately related to, if not identical with the North American *Platanus occidentalis*, var. *acerifolia.* *Liquidambar Europeum*, a Miocene species without relation now in the European flora, but reproduced still in that of our continent; in the family of the Laurineæ the group of Maximieux has *Persea Carolinensis;* in the *Magnolia*, a species similar to the American *M. grandifolia;* and still more, one *Lyriodendron*, a *Tilia* represented now by our *T. pubescens*, and an *Ilex* related to *I. Cassine.* Thus, nine species of this group of thirty-two Pliocene European species belong by identity or close affinity to the present North American flora, while ten only are European; the others being related by nine species to the flora of the Canary Islands and by four to Asiatic types.

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* Ueber Permische Pflanzen von Fünfkirchen in Ungarn, von Dr. Oswald Heer. *Budapert*, (1876.)

† Recherches sur les végétaux fossiles de Maximieux par le Comte G. de Saporta *et le Dr.* A. F. Marion. Lyon, etc. (1876.)

Besides its intrinsic value, Saporta's work has a peculiar interest for the paleontology of this continent, where only, after Maximieux, materials pertaining to a pliocene vegetation have been obtained; first from the Chalk Bluffs of the Mississippi, below the mouth of the Ohio, and later and more abundantly from the gold-bearing gravel beds of Nevada County, California. From this last formation fifty species are known, and ten from the former; and of these sixty species, forty-six are American, either identical with or closely allied to some species of our present flora. Of the number, six are already represented in the Lignitic flora of the Rocky Mountains, a fact proving the long continuance of vegetable types on this continent; for the American types of the Pliocene of Maximieux, *Platanus*, *Liquidambar*, *Persea*, *Magnolia*, *Lyriodendron*, etc., are all already present in the American Miocene as in that of Europe, and therefore have not come to us by migration. This subject, however, of transformation and migration of vegetable types is examined with some more details in a memoir on the Pliocene flora of California, now in the way of publication as a new volume on the Geology of California, by Professor J. D. Whitney. It is, therefore, more appropriate to postpone a consideration of it for the present.

8. *Preliminary Note on the Development of Organisms in Organic Infusions;* by JOHN TYNDALL, F.R.S. Received January 18, 1877.—I beg leave to submit to the Royal Society a brief preliminary note of the results obtained in the further prosecution of my researches "On the Optical Deportment of the Atmosphere, with reference to Putrefaction and Infection."

The very remarkable experiments of Dr. Roberts, of Manchester, which have been confirmed by Professor Cohn, of Breslau, have been both verified and contradicted by my recent researches. In some cases alkalized hay-infusions have been completely sterilized by boiling for five minutes, in other cases they have withstood the boiling temperature for a far longer period.

Pursuing with scrupulous exactness the method of experiment devised by Dr. Roberts, and in part followed by Professor Cohn, I have found in other infusions than hay an enormous resistance to sterilization. A single conspicuous example will serve as an illustration. Cucumber-infusion has been subjected, for intervals varying from five minutes to five hours and a half, to the boiling temperature without losing its power of developing life. Two days' exposure to a temperature of 90° Fahr., subsequent to this treatment, sufficed to develop in it swarms of *Bacteria.*

The infusion which thus withstood, in one of Dr. Roberts's "plugged bulbs," the temperature of boiling water for 330 minutes, was completely sterilized in three minutes by boiling it in a small flask with a narrow neck, and hermetically sealing the flask during ebullition. In the case of the "plugged bulbs" the observed resistance was due, not to the germs of the infusion, but to those diffused in the air above it.

I have also pursued my experiments with closed chambers, from which the floating matter was removed by self-subsidence. With certain new infusions introduced into this inquiry failure after failure occurred, two or three days generally sufficing to fill the boiled and protected liquids with Bacterial life. The vegetable infusions usually became turbid throughout; but a characteristic feature of the life developed in all infusions during the last three months was the formation upon their surfaces of a thick and deeply pitted fatty scum. Precautions far greater than those found successful a year ago failed to protect these infusions from contamination.

I resorted to the mode of calcination by an incandescent platinum wire, applied with such uniform success in my last inquiry. The wire was brought close to its point of fusion, the period of incandescence was doubled, and extraordinary care was taken to ward off infection by a ring of cotton-wool. The care proved nugatory; for, in despite of it, swarming life appeared in the infusions afterwards.

I tried to reproduce the results with animal infusions obtained with such ease and certainty a year ago. Some of these old infusions, highly concentrated by evaporation, remain with me to the present hour; they are as clear as distilled water. But in my recent experiments, where the care bestowed far exceeded that found necessary in my last inquiry, the animal infusions, like the vegetable ones, fell, for the most part, into putrefaction.

With hermetically sealed flasks, properly boiled and sealed with due care (I would emphasize this condition), there was no difficulty in sterilizing any of the animal infusions.

By the scrupulous removal of every possible source of contamination I was able finally to maintain some of the most refractory of the liquids operated on perfectly pellucid, in closed chambers from which the floating dust had disappeared by self-subsidence.

It is to be noted that the earliest experiments of this inquiry were quite in harmony with all the results of the former one, and that it was only as time advanced that the singular discordance between recent and former results showed itself in any marked degree. What was the cause of this discordance?

The question is to be answered by reference to the experiments with hay-infusions, which were begun early and were multiplied and varied later on. By practice such a mastery over these infusions was at length attained that, though the same method of experiment was undeviatingly pursued, I could contradict or corroborate, at will, the observations of Dr. Roberts and Professor Cohn.

On analyzing these apparently irreconcilable results, it was found that, in almost every case where five minutes' boiling sufficed to sterilize alkalized hay-infusion, the hay employed was mown in 1876, while in almost every case where the greater resistance to sterilization was shown, the hay was mown either in 1875 or some previous year. The hay found most difficult to sterilize was from Colchester, and it was five years old.

To the drying and hardening of the germs of the old hay by time I ascribe this singular result.

An experiment on artificially dried peas, as compared with the same peas undried, is not without instruction. After boiling for an hour or so, the undried peas become tasteless, while the dried ones retained a considerable amount of flavor. After a couple of hours' boiling the undried peas rendered the water in which they were immersed thickly turbid, the liquid surrounding the dried peas remaining at the same time perfectly clear. The dried peas were rendered soft, but many of the green peas were reduced by two hours' boiling to a mere pulp, the mixture of which with the water rendered it muddy.

The comparative tastelessness of the undried peas proved that their juices, which are an essential factor of their individuality, and probably also of their power of germination, had diffused into the surrounding water. On the other hand, the clearness of the water which embraced the dried peas indicated a restriction of the exchange of matter between the peas and the medium in which they were immersed. The experiment threw light upon the fact that even with four or five hours' digesting, it was impossible to make the specific gravity of the samples of my oldest hay sensibly greater than that of water. The dryness and induration of the old hay thus indicated being shared by the germs attached to the hay, endowed them, I doubt not, with their greater power of resistance.

Experiments have also been made with new hay dried artificially at temperatures varying from 140° to 185° Fahr., an account of which shall be communicated in due time to the Royal Society.

The different samples of hay employed in this investigation were introduced in succession into the laboratory of the Royal Institution, and they ended by rendering the atmosphere of the place so virulently infective that precautions which, under ordinary circumstances, were more than sufficient to secure perfect immunity from external contamination, were found utterly ineffectual.

Thanks to the friendly action of the President of the Royal Society, I was enabled to escape from this atmosphere to a purer air. I had a series of tin chambers constructed, which were not permitted to enter the Royal Institution at all, but were taken straight from the tinman to Kew Gardens. They were mounted in the excellent laboratory recently erected there by the munificence of Mr. Jodrell. In this new position the insuperable difficulties encountered in London disappeared, and the experiments followed the course of those described in my last investigation. Two of the chambers gave way; but on being scrutinized they were found leaky. Five sound chambers, on the contrary, remained perfectly intact, and they embraced the particular substances which had given me so much trouble in London. Infusions exposed to the common air at Kew became rapidly rotten.

A fuller account of these researches shall soon be submitted to the Royal Society. In prosecuting them thus far I have been very ably assisted by Mr. Cottrell and his junior colleague Mr. Frank Valter.—*Proc. Roy. Soc.*, vol. xxv, No. 177.

9. *On Heat as a Germicide when discontinuously applied;* by JOHN TYNDALL, F.R.S. Received Feb. 14, 1877. (Letter addressed to T. H. Huxley, Esq., Sec. R. Soc., and dated Feb. 14, 1877.)—In my "Preliminary Note," communicated to the Royal Society on the 18th of January, various infusions were referred to as manifesting an astonishing resistance to sterilization by heat. This resistance was traced to its source; and I have been since informed that you were good enough to express at the time a very favorable opinion as to the significance and value of the results indicated.

It will, I think, now interest you to learn that the most obstinate of the infusions referred to in the "Note" have been since rendered tractable by the application of very simple means. Following up the plain suggestions of the germ theory, I have been able, even in the midst of a virulently infective atmosphere, to sterilize all the infusions by a temperature lower than that of boiling water.

It is known that the prolonged application of a low temperature is often equivalent to the brief application of a higher one: and you may therefore be disposed to conclude that in the experiments here referred to I have substituted time for intensity. This, however, is not the case. The result depends solely upon the manner in which the heat is applied. For example, I boil an infusion for fifteen minutes, expose it to a temperature of 90° Fahr., and find it twenty-four hours afterward swarming with life. I submit a second sample of the same infusion to a temperature lower than that of boiling water for five minutes, and it is rendered permanently barren.

The secret of success here is an open one. I have already referred to the period of latency which precedes the clouding of infusions with visible *Bacteria.* During this period the germs are being prepared for their emergence into the finished organism. They reach the end of this period of preparation successively—the period of latency of any germ depending upon its condition as regards dryness and induration. This, then, is my mode of proceeding: before the latent period of any of the germs has been completed (say a few hours after the preparation of the infusion), I subject for a brief interval to a temperature which may be under that of boiling water. Such softened and vivified germs as are on the point of passing into active life are thereby killed; others not yet softened remain intact. I repeat this process well within the interval necessary for the most advanced of those others to finish their period of latency. The number of undestroyed germs is further diminished by this second heating. After a number of repetitions, which varies with the character of the germs, the infusion, however obstinate, is completely sterilized.

The periods of heating need not exceed a fraction of a minute in duration. Sum them up in the case of an infusion which they have perfectly sterilized; they amount altogether to, say, five minutes. Boil another sample of the same infusion continuously for fifteen or even sixty minutes, you fail to sterilize it, although the temperature is higher and its time of application more than tenfold that which, discontinuously applied, infallibly produces barrenness.

In a few weeks I hope to bring this entire subject under the notice of the Royal Society.—*Proc. Roy. Soc.*, Feb. 1, 1877, vol. xxv, No. 178, p. 569.

III. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—At the session of the National Academy, held in Washington, April 17-20, 1877, the following new members were elected: Elliott Coues, U. S. A., Washington, D. C.; John W. Draper, New York; Henry Draper, New York; S. H. Scudder, Cambridge, Mass.; C. S. Peirce, Cambridge, Mass.

The following is a list of the papers read at the meeting:

On a new measuring instrument: the vernier microscope; by A. M. Mayer.

On the laws ruling the vibration of tuning-forks; by A. M Mayer.

On the determination of the coefficient of expansion of solids; by A. M. Mayer.

On some remarkable facts in the distribution of magnetism in very long (5 ft. ½ in.) magnets; by A. M. Mayer.

On systematic errors in star declinations; by E. C. Pickering and W. A. Rogers.

Micrometer-level and topographical camera; by E. C. Pickering.

On the young stages of some osseous fishes; by Alex. Agassiz.

The results of deep-sea dredgings; by Alex. Agassiz.

On critical periods in the history of the earth, and their relations to evolution, and on the Quaternary as such a period; by Joseph LeConte.

On the structure of the crystalline lens, and its relation to periscopism; by Joseph LeConte.

On the progressive motion of storms; by William Ferrel.

Contribution to Meteorology; by Elias Loomis. (7th paper.)

Improved method of obtaining metallic spectra; by G. F. Barker.

On the effect produced by mixing white with colored light; by O. N. Rood.

On Newton's use of the term *indigo* with reference to the color of the spectrum; by O. N. Rood.

Internal structure of the earth as affecting the phenomena of precession and nutation: supplementary to article under this head read before the Academy, and published in vol. xiii, Smithsonian Contributions; by J. G. Barnard.

A proposed new method in solar spectrum analysis; by S. P. Langley.
On some researches in the theory of invarients; by J. J. Sylvester.
Peculiarities noticed in the oxidation of aromatic sulpho-acids; by Ira Remsen.
On complex inorganic acids; by Wolcott Gibbs.
Description of a detached gravity escapement; by C. A. Young.
Remarks on the apparent secular acceleration of the mean motion of the moon, as derived from the observations of the ancient eclipses; by Simon Newcomb.
Researches in linear theory; by Geo. W. Hill.
On the structure of the "Henry" Mountains; by G. K. Gilbert.
On the public domain; by J. M. Powell.
Remarks on some artesian wells, along the line of the Union Pacific Railroad in Wyoming Territory; by F. V. Hayden.

2. *Excrementitious deposits in the Rocky Mountain region.*—A paper on these deposits, in Nevada, by H. W. Henshaw (Proc. Acad. Sci. Philad., 1877, 39) sustains the view of Prof. Cope, that they were made by the big-eared rats, a species of *Neotoma*, and probably *N. cinerea*. They consist of vegetable matter, as shown by the chemical analysis of Dr. Lœw, in the volume on Zoology, of Lieutenant Wheeler's expedition. Part have a bitumen-like look, and others vary from this to pill-like excrements. In a crevice of the rocks one deposit had a depth of two feet, and contained also small twigs and some birds' feathers. "The mass was evidently the accumulation of years, and had served as a nest. Throughout was a large amount of hard droppings from which the urine had passed, and whose nature was unmistakable. The urine, charged with a certain amount of excrementitious matters, had filtered through to form the singular deposits." Water or the urine has carried the portions it could dissolve down the faces of walls and deposited it on shelves where no animals without wings could reach, and sometimes on the roofs of cavities. All the regions where these deposits occur are inhabited by the *Neotoma*, which is eminently a vegetarian.

3. *Fourth Annual Report of the New Jersey State Board of Agriculture for the year* 1876. 196 pp. 8vo. Trenton, N. J.—Besides details of economical importance, this Report contains an account of the Green sand beds of the State by Prof. G. H. Cook (Secretary of the Board) with sections, and detailed descriptions, and many analyses of the green sand and clayey marls. All belong to the Cretaceous, excepting the upper layer of the Upper Green sand, which is Eocene Tertiary. The value of the green sand marl, in agriculture, is treated of at length. There is also an account of the Miocene Tertiary marls of the State.

4. *Primer of Chemistry, including analysis;* by A. Vacher. 108 pp. 12mo. London, 1877. (Churchill).—The author states that this little book represents ten years' experience in teaching the rudiments of chemistry and analysis. The term *unit* replaces *atom* and *molecule*, and *antimetal* serves in place of *radical*, and the student is left to guess at the meaning of atomic weight and equivalent, these terms not being found in the book. The science is compressed into a small compass, but the condensation passes the limit of clearness. B. S.

5. *Correction.*—Comet b, 1877, was discovered by Winnecke.

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